Acoustical Society of America

Generalizing How Musical Instruments Work

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Students use their background knowledge to make generalizations about how instruments work.

This lesson was designed for use after the Sound and Music introductory lesson and Musical Instruments Part I and Part II.

Science Topics	Process Skills	Subject Integration	Grade Level
Sound Vibrations Resonance Frequency	Observing Scientific Inquiry Comparing Predicting Inferring	Physical Science Music Musical acoustics Speech	6-12

Time Required			
Advanced Preparation	Set-Up	Activity	Clean-Up
Gather materials	5 minutes	45 minutes	5 minutes

Learning Goals

Students will be able to

- describe resonance and where and how it appears in instruments.
- describe sympathetic vibration and how it relates to instruments.
- use what they have learned to determine how instruments they have not studied in class work.

Materials

- Packets -- 1 per student (See pages 6-9)
- Pasta Noodles – 3 long and dry*
- Raisins or small marshmallows (small)

Optional:

- Projector for the picture

*Have extras in case they break too soon

Advanced Preparations

Please forward any questions or comments to:
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- Complete the Sound and Music Introductory lesson and the Musical Instruments Part I and Part II lessons.
- Gather materials
- Watch pasta noodle demo video for clear instructions on running the demonstration*
    - Lesson demo or at http://www.youtube.com/watch?v=MA8WEFhA3DM&feature=player_embedded

*The pasta demonstration video can be shown to the class, but it is much more effective to actually demonstrate with the noodles in the classroom

Set Up

- Gather materials

Introducing the Activity

Explain that this lesson is a follow up to the two musical instrument activities.

Have the students work either individually or in partners/small groups to begin the activity.

Doing the Activity

Characterizing Instruments

Students will, thinking about the straw and cup instruments, answer questions 1-3 in their packets and discuss with their groups.

☆ *Class Discussion 1*

Facilitate a class discussion on the previous questions.

- The straw instrument and the cup instrument made sound via source of vibration. For the straw it was the reed buzzing and for the cup it was plucking the string caused it to vibrate.
- To change pitch both the straw and cup instrument needed the length changed. For the straw making the tube longer make a lower pitch and with the cup instrument plucking the string at its longest made the lowest not. Also the cup instrument pitch could be changed by increasing the tension in the string.
- To make them loud – amplify the music – the straw instrument has the tube. The vibrations resonate inside the tube which amplifies the sound. With the cup instrument

the cup made it loud. The string made the cup vibrate and the cup has a lot more surface area to move the air making a louder sound.

- The guitar also has source of vibration (plucking strings), a way to change pitch (string length or tension) and a way to amplify the music the hollow body that vibrates when the strings vibrate. Note the electric guitar was not loud because it does not have a way to amplify the sound without an electric amp.

Resonance and Pasta Noodles

Students will continue to work amongst themselves in groups to answer question 4.

This demo was already done in the Sound and Music lesson but I do it again here to remind them and help them visualize resonance after they've had the experience playing with the different instruments this week.

Call all of the students back to attention for the pasta noodle demonstration.

- Hold three sticks of pasta in one end, each held at a different length.
- First shake your hand slowly, and the long pasta will swing vigorously back and forth.
- Shake at a medium frequency for the middle to swing vigorously.
- A high frequency will cause the short one to vigorously wave back and forth.
- Doing any of the three fast enough will cause the past to snap off.

This is a good example of how earthquakes affect buildings.

Students will talk to the rest of their group to answer questions 5-6.

Class Discussion 2

Have the class discuss the previous questions.

- For question 6 I like to use the analogy of a swing. If you push on the swing at the right time, the person goes higher and higher, that's how resonance works. Just as the pasta noodle is about to bounce back to the other side, your hand gives it a little push in that same direction. Each time the pasta bounces back you give it a little push. That means it'll keep going farther and farther each time. That's why you have to wiggle your hand at the right rate. If you push it at the wrong time, it'll just screw up the wiggle. Just like a swing, if you push at the wrong time, you mess everything up and the person barely swings at all.

Resonance and Instruments

Students will resume work in groups. In question 7 students will describe where resonance happened with each of the instruments previously used:

- Straw instrument, tuning fork, cup instrument, your voice, acoustic guitar, electric guitar
- In the tube, on the tines, on the string, in your vocal cords, strings, strings.

Students will compare two scenarios discussing the body of an acoustic guitar in question 8.

☆ *Class Discussion 3*

Discuss the previous questions as a class.

- Jasmine is correct. If the body of an acoustic guitar were vibrating because of resonance, it would only be loud for one note. The natural frequency. Instead, it's loud for the entire range of notes that the guitar can make. So it's Sympathetic Vibration that amplifies a guitar.

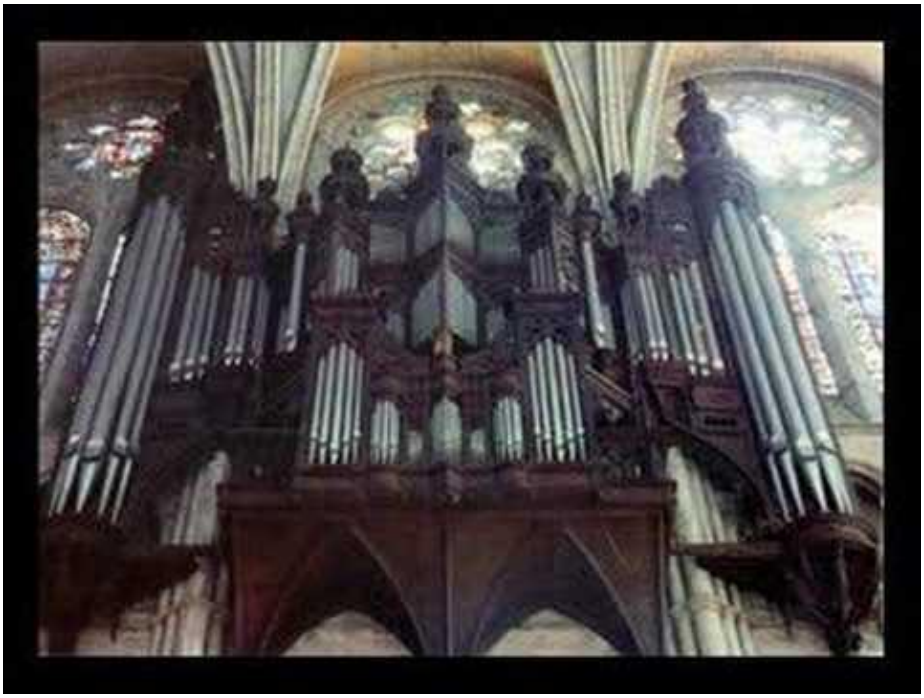
Resonance vs Sympathetic Vibration

Students will determine whether sympathetic vibration or resonance makes the instruments loud, and answer question 9.

- Question 9 Straw Instrument: resonance in the tube, tuning fork: doesn't really amplify, just resonance on the tines, cup instrument: sympathetic vibration of the cup, your voice: somewhat complicated your throat and mouth provide a place for resonance to amplify the sound, our nasal cavities all contribute, acoustic guitar: sympathetic vibration in the body, electric guitar: no amplification unless plugged into an electric amp.

How Does a Pipe Organ Work?

Can project the following picture so students can see it better than the copy in their packet. Students will examine the following picture and explain how they think a pipe organ in a church works, and why they think it has all the different pipes.



Explanation

In-depth background information for teachers and interested students

The explanations are interspersed in the directions to explain the class discussion goals.

Pipe organ: each tube resonates at specific frequency or pitch. That means there is one tube per note that the organ plays. The source of vibration is air that is pushed through the pipes which is called wind. It's a continuous source so the note can be sustained as long as the key is depressed. What makes it loud is both the resonance in the tubes and sympathetic vibration of the case.

Key Terms:

- Natural frequency – the frequency at which an object likes to vibrate.
- Resonance – When one object is vibrating and it is put in contact with another object, if the *frequency* of the first object is at the *natural frequency* for the second object, the second object will start vibrating vigorously at its *natural frequency*. (pasta demo is an nice clean example of resonance)
- Sympathetic vibration – When a *vibrating* object causes another object to vibrate at the same *frequency*, which may or may not be a *resonance* frequency. For example, if you place the handle of a vibrating *tuning fork* onto a table it becomes a *soundboard* and will vibrate at the same frequency. The table top moves more air than the tuning fork so the sound is louder. A piano string causes the *soundboard* of a piano to vibrate at the same *frequency* as the string.

- Pitch – How low or high a tone sounds to a person – it is how a person hears the *frequency* of a sound.
- Tone – a musical sound of a specific frequency or pitch
- Vibrations (oscillations) - a shaking back and forth movement

Optional Extensions /Modifications

Modifications:

- Project the picture on the screen for students who have trouble with vision.
- Visually impaired students may need a church organ to be described to them
- Hard of hearing students can feel the vibrations, and use what they have felt to answer the questions.
- Have students use the pasta and raisins themselves investigating how different lengths of pasta, maybe 2 raisins or 2 pastas together change the frequency that causes them to resonate.

Generalizing how musical instruments work

Name: _____

1. What were the three characteristics that the straw instrument needed to 1. make sound, 2. produce a variety of notes and 3. be loud?

2. What were the three characteristics that the cup instrument needed to 1. make sound, 2. produce a variety of notes and 3. be loud?

3. Can these three important features be generalized for all instruments including your straw, cup, and guitar?

☆**Stop – class discussion**

4. What is natural frequency?

5. What is resonance?

6. How is it possible for one pasta to wiggle a lot while the other two that were being held don't wiggle much?

7. Show when the "push" from the hand has to happen for a pasta stick to resonate. For example, if the pasta is about to bounce back to the right, which way does your hand have to push?

☆**Stop – class discussion**

8. Where is resonance happening (resonance determines the pitch) with each of the instruments we worked with this week?

    a. Straw instrument

    b. Tuning fork

    c. cup instrument

    d. your voice

    e. acoustic guitar

    f. electric guitar

9. Two students are discussing the body of an acoustic guitar. Which, if either, student do you agree with and why?

   Kaiya: I think the body of an acoustic guitar is a resonance chamber and is what makes the guitar loud.

   Jasmine: I don't think it is a resonance chamber because a resonance chamber only supports a certain tone like a flute or the water bottles. When you change its length it likes a new tone. Acoustic guitars can play a really large range of notes so I don't think the body can be a resonance chamber.

☆**Stop – class discussion**

10. What makes each of these instruments loud? Resonance or Sympathetic Vibration? Where is the amplification happening and why do you think this?

	Resonance or Sympathetic Vibration?	Where is amplification?	Why do you think this?
a. Straw instrument			
b. Tuning fork			
c. cup instrument			
d. your voice			
e. acoustic guitar			
f. electric guitar			

11. Based on what you've seen today and this week, how do you think a pipe organ in a church works? Why does it have all the different pipes?