and the nature of a chemical. Energy is transferred in many ways.

3. Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.

The Benchmarks for Science Education

1. Things that make sound vibrate.

2. Something can be "seen" when light waves emitted or reflected by it enter the eye—just as something can be "heard" when sound waves from it enter the ear.

3. Vibrations in materials set up wavelike disturbances that spread away from the source. Sound and earthquake waves are examples. These and other waves move at different speeds in different materials.

4. Waves can superpose on one another, bend around corners, reflect off surfaces, be absorbed by materials they enter, and change direction when entering a new material. All these effects vary with wavelength. The energy of waves (like any form of energy) can be changed into other forms of energy.

Glossary

Amplitude - of a sound wave is the amount of motion of air molecules within the wave. The greater the amplitude of the wave, the harder the molecules strike the eardrum, and the louder the sound that is perceived. Behaviors of **Sound** - Like light, sound is subject to reflection, refraction, diffraction, and interference. Reflections of sound obey the fundamental law that the angle of incidence equals the angle of reflection. Refraction bends sound waves from their original path. If sound from a single source reaches a listener by two different paths— one direct and the other reflected— the two sounds could reinforce one another or interfere negatively, so that the resultant sound is actually less intense than the direct sound without reflection.

Characteristics of Sound - simple sounds can be described by three perceived characteristics: pitch, intensity, and quality. These result from three physical characteristics: frequency, amplitude, and harmonic constitution.

Frequency - of a sound wave is the number of waves passing a point in one second.

Longitudinal Wave - A sound wave is a longitudinal wave in which air molecules move back and forth in the same direction as the wave motion so that each molecule passes energy on to neighboring molecules. **Oscilloscope** - is an electronic instrument that records changes in the voltage of an electric or electronic circuit by a trace of light on the face of a cathode-ray tube. Special converters attached to an oscilloscope can convert sound waves into electrical impulses that can be observed.

Pitch - in sound and music refers to the highness or lowness of a musical tone as determined by the frequency of the vibrations producing it. Standards of exact pitch have varied over the centuries and among countries. The international standard for **A** above middle **C** is **435 Hz** (vibrations or cycles per second), while Great Britain and the United States use **A = 440**.

Resonance - is the intensification and prolongation of sound, especially of a musical tone, produced by the sympathetic vibration of another substance.

Sound - is a mechanical wave that depends on the physical quality of waves traveling through air that stimulates the sense of hearing and is usually extended to include waves in liquids or solids.

Speed of Sound - in dry air at a temperature of **0° C (32° F)** is **331.6 m/sec (1088 ft/sec)**. As the temperature is increased, the speed of sound increases. The speed of sound in gases depends on the density of the gases. If the molecules are heavy, they move less readily, and sound travels more slowly. Sound generally moves faster in liquids and solids than in gases and is dependent on their densities.

Timbre - is the ear's perception of the quality of a sound created by a series of subsidiary vibrations that accompany a primary, or fundamental, wave-motion vibration. This quality allows us to distinguish among different sounds of the same pitch and volume.

Transverse Wave - is a wave where the direction of pulse of the wave is perpendicular to the direction of wave motion, for example, waves on water. **Wave** - is a pulse of energy that travels through a material, but after the wave has passed the material remains about as it was before the wave's passing.

Review and Extension Questions

1. Describe examples of how vibrating objects can produce sound.

2. Explain how changing the rate of vibration changes the pitch of a sound.

3. Describe several examples that demonstrate how sound has energy.

5. Explain how energy is transferred in the production and transmission of sound.

6. How are sound waves like seismic waves, waves on water, and light waves?

7. Describe several examples that demonstrate that sound travels at different speeds in different materials.

8. Describe evidence that shows that sound waves can superpose on one another?

9. Describe several examples that demonstrate that sound can bend around corners.

10. Describe several examples that demonstrate that sound can reflect off surfaces.

11. Describe several examples that demonstrate that sound can be absorbed by materials they enter.

Science Fundamentals

Let's Form A Band

Understanding Sound

KF522

TEACHER'S GUIDE

Video Purpose

This video is designed to develop students' understanding of characteristics and behaviors of sound by using common examples that motivate students to learn more. This video may be used to introduce new concepts, to support learning activities, or to assist with summarizing concepts.

While students have little difficulty understanding vibrations when treated descriptively, developing an understanding of waves present a greater challenge. Although wave motion is familiar to students through their experience with water, they still might not know how they relate to sound, what they have to do with motion, or in what sense sound waves are waves. Students should come to understand qualitatively the relationship of **speed = wavelength x frequency** before they can understand a quantitative approach. Students should be helped to develop strong semiquantitative notions about waves—for example, higher frequencies have shorter wavelengths and those with longer wavelengths tend to spread out more around obstacles.

Video Activities:

1. Comb - introduces the concept that vibrations produce sounds and that sounds can be amplified.

2. Slinky - introduces the characteristics and types of waves.

3. Aluminum Pipe - demonstrates how two different types of vibrations in a pipe can produce two different sounds.

4. Boom - demonstrates how solid objects can amplify and carry sound.

5. Twang - demonstrates the relationship between the frequency of vibration and the pitch of a sound.

6. Oscilloscope - demonstrates how common sounds are really complex mixtures of vibrations that allow us to identify many different sources.

7. Singing Glass - demonstrates how vibrations can cause objects to resonate and produce amplified sound levels.

8. Bottle Organ - is a discrepant (counterintuitive) event designed to arouse interest by conflicting with expectations and understanding and to stimulate interest in other possible explanations. It involves comparing the sounds produced by tapping identical bottles with different amounts of the same liquid or different liquids and the sounds produced by blowing across the tops of the bottles.

Student Naïve Conceptions

As students grow up they have many experiences for which they form explanations based on a variety of anchoring experiences, such as, playing musical instruments, hearing echoes and watching waves on water. While these explanations make sense for the student, they may conflict with the results of science investigations, and they are sometimes called naïve conceptions. Student's naïve conceptions should not be treated as wrong as such but as conceptions based on insufficient analysis of their experiences. The activities in this video are designed to help students recognize their explanations and develop a more analytic view. Students in middle school are usually at different points in their conceptualization of sound and its behaviors. Young students may have a number of naïve conceptions about sound, such as:

Sound cannot travel through solids and liquids.

Sound can travel through a vacuum, such as space.

Sound can be produced without using any materials.

Hitting objects harder changes the pitch of the sound produced.

These naïve conceptions about sound can persist if they are not appropriately addressed. As teachers, we speak of sound vibrations from sources as diverse as tuning forks, vocal cords, tapping, and blowing into bottles and unless care is taken to connect these diverse methods of generating sound to common principles, confusion of young students will likely result. Because students may not consider air as substantive matter, they may continue to believe that sound can travel through a vacuum and not consider sound as a form of mechanical energy. Connecting the concept of sound to waves may also cause confusion since sound waves are not observable like water waves.

Telling or showing students the explanations that science uses may not change their beliefs. There are several strategies that can be used to facilitate a deeper understanding. Students need to become aware of their own preconceptions about a concept and expose these beliefs by sharing their ideas with other students in small groups in an uncritical environment to help them begin a deeper analysis of their experiences. They should be encouraged to make predictions based on their conceptions before activities begin. This will help students to begin to confront and test their beliefs and provide motivation for looking for other plausible conceptions.

Students need to have time to work toward resolving conflicts between their ideas and their observations, thereby accommodating new concepts. Students need opportunities to extend new concepts by trying to make connections between the new concept and other situations in their daily lives. Students should also be encouraged to go beyond these initial steps by choosing additional questions or problems related to the concept to expand their understanding. These strategies are used to organize suggested activities into the following groups: exposing beliefs, committing to outcomes, confronting beliefs, accommodating concepts, extending concepts, and expanding inquiry.concepts, and expanding inquiry.

Sample Support Activities

Exposing Beliefs

Use an activity like "Think, Pair, and Share" to have students began thinking about their explanations of topics, such as, what causes sounds, and then share their ideas with a partner. Two pairs can then be combined to share their views and each group of four can have a one person share the different explanations. Moving from small to whole group in a secure and uncritical environment gives students an opportunity to see that others are also uncertain and bring a variety of views to their experience.

Committing to Outcomes

Use the different activities in the video as opportunities to have students predict what they think will happen, for example, in the "Bottle Organ" activity. Simply stop the video just before the professor taps or blows on the bottles and have students share with a partner or write their predictions of what will happen. It is important that they make a verifiable commitment so that they can begin to address their beliefs.

Confronting Beliefs

Have students test their ideas by recreating one of the activities on the video or related activities that they found interesting. For example, pairs of students carry-out the "Boom" or "Twang" activities or other video activities and describe their observations and explanations. Working in small groups, students could then debate their explanations, conduct interviews, and check written materials before presenting their results. This is an opportunity for students to confront their beliefs.

Accommodating Concepts

Students need to begin to question their observations and their discussions to help them process information and begin to make sense of the explanations behind the observations. During this time, students begin to resolve the conflict that may exist between beliefs and observations. Class presentations of observations of activities and explanations along with carefully posed teacher questions and follow-up small group discussions will assist with the process of accommodating new concepts.

Extending Concepts

Asking students to give examples of where they have seen the concept discussed or demonstrated or giving examples of how they thing the concept is connected to other situations will help students extend their understanding of the concept.

Expanding Inquiry

To encourage students to continue thinking about the concept, opportunities should be provided that invigorates them to investigate additional questions and problems that interest them.

Correlations to National Standards

The video activities and content address the following National Science Education Standards or The Benchmarks for Science Education *

National Science Education Standards

1. Sound is produced by vibrating objects. The pitch of the sound can be varied by changing the rate of vibration.

2. Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei,