Can You Hear Me Now? – Exploring the Science of Sound

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Overview

This unit on sound is intended to support and enhance the School District of Philadelphia's third-grade Science Core Curriculum. Throughout the unit, students will consider these questions: What is sound? Where does sound come from? How does sound travel? What are the characteristics of sound? How is sound heard? How does this relate to musical instruments?

I am a computer teacher at Overbrook Elementary School, a K-5 school located in Philadelphia, Pennsylvania. My teaching assignments include supporting the curriculum with technology and working with individual classes on projects. The four-week curriculum unit will be a partnership of science lessons with language arts and technology. It is designed for primary students in third grade but can certainly be fleshed out for upper elementary students in fourth and fifth grades. In this unit students will have opportunities to study about the science of sound as well as participate in the hands-on doing of science. The class consists of 30 inner-city students. They have experience using the computer and most of the applications mentioned in this unit.

Rationale

Before children come to school they have a natural curiosity. They want to know how things work and where things come from. As they investigate the world around them, they persist in asking a series of "whys." These early explorations build the framework for their later learning and investigations. In this unit on sound, I hope to enable students to consider the experiences they have had with sound, examine them more closely to reveal physical components, and make personal connections to the material and scientific concepts.

Sound is a significant part of our lives. Through speech and hearing we communicate with others. Through sound we are warned of danger, entertained, and at times annoyed.

Cell phones, alarms, music and screeching tires are common sounds we experience every day. Truly, we are surrounded by sound in our daily lives.

The study of sound is called *acoustics*. It is a branch of physics that studies how sounds are created, transmitted, and received. The word *acoustics* also refers to quality of sound in a room or hall. Understanding sound is important for designing auditoriums, hearing aids, recording devices and speakers. Architectural acoustics deals with making rooms and buildings quiet and conducive to listening to music. Environmental acoustics has to do with controlling noise pollution from motor vehicles, aircraft, and industrial plants. There are many career opportunities dealing with acoustics, and understanding wave behavior is a good foundation for exploring them.

What Is Sound?

To understand sound, we must first investigate vibrations and wave motion. The idea that sound is associated with vibrations is not easily recognized by children. They can easily detect sources of sound and describe some of its qualities. However, the ripple effect is more readily seen in water waves than in the propagation of sound waves. They can visualize dropping a stone into a pond and seeing a series of waves traveling outward from the point where the stone struck. Students need demonstrations; models and comparisons to better understand how invisible sound waves push through the air from the vibrating object to their ears.

We cannot see sound waves but we can hear them. Human sounds, animal sounds and musical sounds are part of our everyday experiences. In all of these, the sound we hear starts with a vibrating object and moves from one location to another through a medium. The medium is anything that has molecules touching each other. An initiating event like a bell ringing or a pencil tapping disturbs nearby molecules and pushes them into each other. They in turn bump the ones next to them, etc. The bumping energy moves from the sound source to our ears through waves. Sound is the energy that is transported when an object vibrates in a medium.

Waves

A stadium wave is a good concrete example to use in introducing students to the concept of waves. Many are familiar with “doing the wave” at a sports event. When people in a stadium do a wave, no one moves in the direction of the wave. They rise up from their seats, swing their arms up high, and then sit back down. The wave is passed as each person becomes momentarily displaced and then returns to the seat as the wave passes by. This concept of a stadium wave provides a context for visualizing wave motion as the movement of a disturbance without the movement of matter. [1]

A slinky is another example to use in introducing students to the concept of waves. Using online animations, students will be able to see the vibrations of the coils. While the slinky is stretched out from one end to the other in its equilibrium or rest position, repeatedly vibrating the first coils will introduce a disturbance or wave motion that can be seen traveling from end to end. Each coil can be seen moving out of its place and then back to its original position. The coils move in the same direction (vertically or horizontally) as the vibrations of the first coils. The slinky wave demonstrates to the students that a wave is a repeated or periodic disturbance that travels through a medium from one location to another.

Transverse and Longitudinal Waves

Transverse and longitudinal waves are two basic types of wave motion. A transverse wave is a wave that causes a disturbance in the medium perpendicular to the direction of the wave's propagation. A longitudinal wave is a type of wave that has vibrations along or parallel to the direction of the wave's movement. The motion of the medium is in the same direction as the motion of the wave.

Transverse waves are easily recognized. A ripple in the water or a wave on a string is a good example of a transverse wave. In the water wave, the water molecules move up and down while the wave move horizontally. In the string, the particles in the medium (string) move in a direction perpendicular (up and down) to the direction that the wave is traveling (left to right). The particles do not move along with the wave. They simply oscillate up and down about their individual equilibrium (rest) positions as the wave passes by. In these transverse wave motions, energy is transported without transfer of matter. Transverse waves include electromagnetic waves, such as radio waves and x-rays.

Longitudinal waves are not as easy to visualize. The slinky is a good visual example of the motion in a longitudinal wave. If we vibrate the first loops of a horizontally stretched slinky in a horizontal direction, the first loops of the medium vibrate and transmit the disturbance to the next connected loop continuing from end to end in a direction parallel to the medium. The particles in the medium oscillate in the same direction as the way the wave is traveling. Energy is again transported without transfer of matter.

Sound waves, which are longitudinal waves, behave in a like manner. As the wave passes through a medium, the particles in the medium (solid, liquid, gas) oscillate back and forth about their equilibrium position. Sound waves are longitudinal waves because particles of the medium through which the sound passes vibrate in a direction that is parallel to the direction in which the sound moves. It is the disturbance that travels, not the individual particles in the medium. When you hear someone speaking, sound waves are carrying energy from one location to another, even though the air molecules only move back and forth a little bit.

Sound Propagation

The illustrations above are examples of mechanical waves. Mechanical waves require a medium (gas, liquid, solid) to propagate a disturbance from one location to another. Electromagnetic waves, on the other hand, are waves that do not require a medium to propagate. Electromagnetic waves can travel through a vacuum. Light is an example of an electromagnetic wave. A person standing on the moon would not hear a shout from another person because sound cannot travel through a vacuum (space). There are no air molecules to move the sound from one location to another. We can see light from the sun because light can transport energy through empty space and does not require a medium to propagate.[2]

We are mostly aware of sound traveling through the medium of gas (air). We can hear a person talking across a room or hear the orchestra from a seat in the balcony. Sound also travels through the medium of water (liquid). Whales communicate with each other when they are miles apart. Sound travels through the medium of a solid (wooden door). You can hear sounds from a room more loudly if your ear is pressed against the door because the door is large and “scoops up” more energy.

Sound waves travel faster through a stiffer medium because energy is transferred more easily through tightly packed molecules. In solids and liquids, the molecules are closer together. Consequently, sound waves travels faster through water than air, and faster in wood than in water. Elasticity refers to how well a medium can return to its original position after being disturbed. In a medium with high elasticity, the material bounces right back to its original shape after the force is removed. The molecules in elastic materials transfer energy more efficiently.[3]

Characteristics of Sound

Sound waves can be characterized by amplitude (volume), wavelength (speed), and frequency (pitch).

Amplitude

One way of measuring a wave is determining its amplitude. The amplitude is the maximum distance the wave moves from its equilibrium or rest position. In a transverse wave we measure the height of the crest (point of maximum upward or positive displacement along the wave) or the depth of the trough (point of maximum downward or negative displacement along the wave).

In sound waves, which are longitudinal, the amplitude is the maximum distance a particle is pushed or pulled from the rest position. The amplitude of a sound wave is closely related to its loudness and is associated with the level of force that is used to introduce the disturbance. Scientists measure amplitude of sound waves in decibels. The term is derived as an honor to Alexander Graham Bell, who did much of the preliminary work in the modern science of acoustics. Leaves rustling in the wind measure about 10 decibels; a jet engine is about 120 decibels. With the leaves, the level of disturbance is low, whereas with the jet, the disturbance is higher. As the sound wave spreads out from its source, the amplitude or loudness decreases.[4]

Wavelength

The wavelength in a transverse wave is the distance from one crest to the next crest or from one trough to the next trough. In the case of a longitudinal wave, measuring the distance from compression to the next compression or from a rarefaction to the next rarefaction makes a wavelength measurement.[5]

Speed of Sound

When we speak of speed of sound we are referring to the speed of sound waves passing through an elastic medium. The speed varies with the medium as noted above, but also it varies with the properties of the medium, especially the temperature. When we speak of speed of sound we are usually referring to the speed of sound in air. Under normal atmospheric conditions, the speed of sound at room temperature is 344 meters per second or 770 miles per hour. [6]

Frequency

We can measures the time it takes to complete one wave cycle. This is called the period. To measure how often a cycle occurs in a wave, we measure the wave's frequency. which is the reciprocal of the period (one divided by the period). A wave has a high frequency if a cycle is repeated many times in a second and a low frequency if a cycle does not have many repetitions. Sound waves can have a wide range of frequencies.[7] Scientists measure sound frequencies in hertz. The number of hertz is the number of vibrations made in one second.

Humans can hear sounds between 20 and 20,00 Hz. This is a very wide range. However, as we get older, we loose the ability to hear higher frequencies. Some animals can detect lower or higher frequency sounds than humans. The hippo, rhino, giraffe, alligator, tiger and elephant are animals that can hear lower frequencies (less than 20 Hz.). Scientists have discovered that elephants can hear very low frequencies sounds from five miles away. Bats, cats, dogs, mice and dolphins are some animals that can hear higher than human hearing (greater than 20,000 Hz.) [8] This explains why a dog can hear a special whistle that humans can't.[9]

Pitch

It will be important to help students distinguish between sounds that are loud and soft (amplitude) and sounds that are high or low frequency (pitch). The pitch of a sound is determined by the frequency. It is the high or low tone of the sound that we perceive. The shorter wavelengths will go by more frequently. Shorter wavelengths mean more waves per unit of time; therefore, higher frequency, higher pitch. Likewise, longer wavelengths mean fewer waves per unit of time; therefore, lower frequency, lower pitch. Instead of talking about frequencies, musicians name the pitches they use most often. For example, when tuning their instruments they might agree that playing middle C on the piano keyboard would be 256 Hz.

Musical Instruments

The instruments of the orchestra are grouped into four families: Strings, Brass, Woodwinds and Percussion. Within each family, the instruments share similarities, such as: how they are constructed, the materials used to make them, and how they produce sound. The Dallas Symphony Orchestra's website provides an interactive world of musical fun and learning for students.[10] Each section of the orchestra can be explored fully. Likewise, The American Symphony Orchestra League's website offers explanations and audio examples of each section of the orchestra.[11] These brief descriptions are starting points for further explorations.

Strings

Stringed instruments produce musical sounds when the player makes one or more strings vibrate. They are made of wood pieces glued together. On bowed instruments, such as the violin, the player draws the bow back and forth across the strings. The pressure of the bow on the strings produces vibrations that are amplified by the body of the instrument, which is hollow. The strings are made of nylon, steel or animal gut and are wrapped around pegs at one end and attached to a tailpiece at the other. The strings are stretched across a bridge to produce a different pitch. To produce other pitches, the player shortens the string by pressing down on it with the fingers. On plucked instruments, such as a guitar, the player plucks the string with fingers or a pick. At times the strings of a violin or other bowed instruments are also plucked for special effects.

Woodwinds

Woodwinds are a type of wind instruments. At one time they were made of wood but now are made of medal or other materials. In some of these instruments, such as a recorder, the player blows through a mouthpiece into the instrument. In other instruments such as a flute, the player blows across a hole in the instrument. Yet others, such as a saxophone, are called reed instruments because the have one or two reeds attached to the mouthpiece. The reeds vibrate when the player blows on them. By placing fingers on the holes, the player controls the pitch by lengthening or shortening the column of air that vibrates inside the instrument.

Brass

Brass instruments are also wind instruments but are played differently than woodwinds. The player presses the lips against the mouthpiece so that they vibrate like reeds when the player blows. By adjusting the opening between the lips, the player produces higher or lower pitches. Valves that lengthen or shorten the tube through which the air is blown also control the pitch. The main instruments of the brass family include the trumpet, horn, trombone, and tuba. The trombone has a slide instead of valves. The trumpet is the highest sounding member of the brass family and the tuba is the lowest.

Percussion

Instruments in the percussion family are played by being struck, shaken or scraped. Most Western drums do not produce a range of pitches. The kettledrum can be tuned to various pitches by adjusting the tension of the drumheads. The xylophones have a series of bars that produce a range of pitches.

Keyboard instruments are often classified as percussion instruments. However, most keyboard instruments are not true members of the percussion family because the vibration of a membrane or solid material does not produce their sound. For example, sound is produced on the piano by small hammers striking strings. The hammers are controlled mechanically and strike the strings when the player's hands press the piano keys.

Objectives

The main objective of this unit is to investigate key concepts involved in understanding the science of sound. Students will heighten their awareness of sound by observing, comparing and describing sounds. They will understand that sound is a form of energy that travels in invisible waves known as compression waves. Students will experiment with sound traveling through different mediums, including solids, liquids, and gases. They will investigate the characteristics and behaviors of waves and the important role waves have in the study of physics. They will discover how technology helps us investigate and understand the science of sound, as well as enjoy its applications in our daily lives. They will understand how the study of science in general and the study of sound in particular help us understand and improve our word.

Standards

The ideas presented in this unit are appropriate for third grade students studying the concept of sound and its wave nature. They provide a basic understanding of sound terms such as frequency, amplitude and wavelength. This unit will provide a framework for further investigation of the science of sound including real world applications.

This unit will help students fulfill the Pennsylvania Academic Standards for: Science and Technology, and for Reading, Writing, Speaking and Listening. These standards will be listed in the appendix.

Strategies

I will work in partnership with the third grade teacher. Some of the lessons will be conducted in the classroom and others in the computer lab. We will put together a reading list of books that students will read independently to support their learning. These books will be chosen for various reading levels of the students and for their illustrations and applications of concepts. In our primary grades, students participate in the *100 Book Challenge Program*. The goal is to read 100 books during the school year. They either begin or end the day with a 30-minute period of reading as well take books home. We will have books dealing with sound available throughout the unit. I have listed some of the books in the Student Resources section.

Whenever and wherever possible, I intend to use available technologies to enable students to learn from and learn with specific applications. For example, they will use the application *Kidspiration* to brainstorm a list of sounds they hear and then categorize them as loud or soft. Other sounds will be characterized as high or low. Students will work with a partner to create a PowerPoint presentation that explains and illustrates key vocabulary. Students will view short online videos to introduce and reinforce scientific understanding of hearing and the science of sound. Throughout the unit, students will use online animations to reinforce concepts and to observe changes in amplitude, frequency, and pitch of wave motion. Students will use tape recorders to record sounds from the environment and from the making of sounds with objects in the classroom.

They will also keep a science journal to document their activities, reflect on what they have learned, compile a glossary of terms, and record interesting facts, and list questions for further learning. This work will assist students in our culminating project of creating a podcast on what they have learned about the science of sound.

Classroom Activities/Lesson Plans

Lesson Plans

Lesson 1: Thinking About Sound:

Objectives: Students will begin an inquiry into the science of sound. They will distinguish between loud and soft sounds, and high and low sounds. They will discover that sound loses energy as it travels from its source. They will know that the volume and pitch of a sound can be changed.

Duration: One period: 45 minutes

Procedure

I will begin with a recording of various sounds and ask students to identify them: ice cream truck, whistle, siren, hands clapping, alarm, musical instruments, and voices. Students will listen a second time and determine if the sounds they hear are loud or soft. I will then select the whistle, siren, and musical instruments to help students distinguish between sounds that are high or low. They will record their responses in their science journal. We will then discuss their responses and come to an understanding of key words. Students will keep an ongoing glossary of terms in the back of their journals.

- Noise - any kind of sound but often used to identify unpleasant or annoying sounds (siren, alarm, loud talking or music)

- Sound: a form of energy resulting from vibrating objects in a medium (may or may not be heard by humans)
- Vibration: a back and forth movement
- Volume: the loudness or softness of a sound
- Pitch: the high or low of a sound

Students will then come to the computer room and use an interactive website to experiment with varying distances from a sound source, and changing the volume and pitch of sounds. They will position an ice cream truck closer or further from a person on the sidewalk, watch the difference between a gently and a firmly tapped ruler on the edge of desk, and pluck stings of various lengths on a guitar. [12] Students will bring the lesson to closure by using an interactive quiz to check their understanding of how sound changes.

Lesson 2A: How Does Sound Travel

Objectives: Students will observe animated wave motions. They will participate in a stadium wave to better understand wave nature and how sound travels in waves.

Duration: Two periods: 45 minutes each

Procedure

We will begin by using the software, *Kidspiration*, to create a graphic organizer to represent the three states of matter and list sounds that might travel through them. Students can add images and record a few samples of sound. (Their voice, the clicking of the keyboard, bell ringing, etc.) We will discuss their lists and clear up any misconceptions.

Next students will view animations of a slinky, a cartoon-like interactive stadium wave, and a stadium wave at football game. The links to these sites will be bookmarked on their computers.[13] After viewing these clips, we will discuss what was similar in these examples.

- When people in a stadium do a wave, no one moves in the direction of the wave. As the wave travels, the people remain in their seats. The wave is the disturbance (people jumping up and sitting down again).
- In the example of the slinky, the wave is seen traveling from one end to the other. The coils are temporarily displaced and then return to their original position.
- Wave motion was observed both up and down and side to side.
- Wave motion traveled through a medium.

As a follow-up activity, we will line up in the schoolyard with another class of students to demonstrate wave motion. For the traditional stadium wave, students will have their hands on their knees. After the first student lifts arms overhead and returns them to knee position, students will follow suit when they feel the completed motion beside them. To illustrate the wave of the slinky, students will start with their arms out straight in front of them, and as the wave goes by, each student will swing arms toward and then away from next person in line. Students can take turns watching the wave as they experiment with different motions, (bumping into each other, hopping in place). [14] When they return to the classroom, they will write in their journals what they learned about wave motion.

Lesson 2B: How Does Sound Travel in States of Matter

Objectives: Students will observe, record and compare how the same sounds travels through the different states of matter: solids, liquids and gases

Duration: One period: 45 minutes

Procedure

Students will log on to the K12 Online Resource[15] and select the activity called, "What's the Matter?" I will draw their attention to the sound chamber that includes two gauges: one for fast and slow, and another for soft and loud. They will identify the substances with their corresponding state of matter. The ones included are air, water, oil, wood and concrete. Students will make predictions about how sound will change as it travels through each of these substances.

Students will drag an object into the chamber and observe the sound wave traveling from the speaker (source) to the receiver (ear). They will listen to the sound for each substance. As students test one substance at a time, a numerical value is assigned. This value does not correspond to a unit of measurement. The numbers indicates that the larger the number, the greater the speed or intensity. Students can record the results on a data sheet for comparison.

We will conclude the lesson by reflecting on why the same sound (girl reciting poem) sounded differently as it traveled to the ear through different states of matter.

Lesson 2C: How Does Sound Travel in States of Matter

Objectives: Students will observe and compare how different sounds travel through the different states of matter: solids, liquids and gases.

Duration: Two periods: 45 minutes each

Procedure:

The class will be divided into two groups. One group will stay at their desks to work on an assignment about sound traveling from a source to the ear. They will read pages in their textbook[16] and then illustrate an example of sound traveling from a source to their ears (fire engine, teacher talking, starting signal at a race). They will be instructed to draw lines around the object to show that the sound is moving away from it. They will also work on their glossary in the back of their journals. They will have an opportunity to make connections to other curricular areas. For Math, given the facts that sound travels about 344 meters per second and almost five times faster in water than air, and three times faster in wood than water, students will calculate the speed of sound through water and wood. For Language Arts they will read about a marine mammal biologist and the importance of knowing how sound travels in water in order to help the animals she studies.[17]

The other group will work in pairs and rotate around the class. They will visit three stations where they will observe, record and compare sounds traveling differently through mediums. They will have a recording sheet to record their responses At Station One they will use a clicker to compare sounds in air, in a pail of water and through a small wooden block pressed to their ear while shutting out sound from the other ear. At Stations Two and Three the same procedure will hold as students tap a pencil on a wooden block and bang small rocks together. When both groups have completed the rotation and the assignments, we will discuss and summarize findings. As a follow up activity, students will be encouraged to compile a list of careers that deal with the science of sound

Lesson 3A: Sound and Pitch

Objectives: Students will recognize that vibrations can be changed to alter the pitch of a sound.

Duration: One period: 45 minutes

Procedure:

I will begin with a video clip from Teachers' Domain to introduce vibrations and pitch.[18] Students will distinguish between loud and soft sounds noticing that the loud sounds result from stronger vibrations. They will listen to singers, insects and underwater animals to distinguish between high and low pitched sounds observing that the faster something vibrates the higher pitched it sounds. Students will practice singing high and low notes as they touch their throat to feel the difference. We will review the concept that sound is produced from a vibrating object and the faster the vibration, the higher the pitch.

Then students will explore the concept of pitch as they experiment with rulers vibrating over the edge of their desks and hold one end down firmly. They will pluck the ruler being careful not to hit the desk. They will test out different lengths of the ruler extending over the desk. They will think about what they saw and what they heard as they compare the results of the shorter and longer lengths. (Shortening the length of the ruler that hangs off of the desk causes the ruler to vibrate faster when it is plucked. This raises the pitch)

For an extension, students will work in teams of six to play a tune with different lengths of rulers measured with centimeters. One example is: 14, 14, 10, 10, 9, 9 10, 11, 12, 12, 13, 13, 14. The tune is "Twinkle, Twinkle Little Star."[19]

Lesson 3B: Sound and Pitch

Objectives: Students will examine the relationship between the length and tension of an instrument's string and its resulting pitch.

Duration: Two periods: 45 minutes each

Procedure:

The violin teacher at our school will present a brief lesson on parts of an orchestra in general and stringed instruments in particular. She will demonstrate to the class the relationship between the tension of the violin's string and its pitch helping students realize that the tighter the string is, the higher the note will be. The students who take violin lessons will also bring their violins. Students will be arranged in small groups to get a closer look and clearer hearing of the sounds. The violin teacher will instruct her musicians what to do and they will demonstrate it to their small groups. Perhaps, with her permission other students will have the experience of creating sounds of different pitches.

Students will then come to computer room to experiment with a virtual harp.[20] As they assemble the harp, they will see the vibration and hear the pitch of each string. When the harp is completed, students can pluck the strings to create a melody. Students will then experiment with another virtual harp to play the tunes, "Happy Birthday" and Twinkle, Twinkle, Little Star." They can observe the relationship between length of string and pitch.[21]

Students will reflect in their journals how the musician can change the pitch on the violin and the harp.

Lesson 3C: Sound of Music

Objectives: Students will explore different sections of the orchestra.

Duration: Two periods: 45 minutes each

Procedure:

Students will visit the website of *The American Symphony Orchestra League* to explore sections of the orchestra.[22] Each section is briefly explained with a list of its instruments. Students can then select individual instruments. As they listen to the music, they view an animation of how the instrument is played narrated by a "cool music kid." Each section of the orchestra has an interactive game to play.

- Strings: students select an instrument and virtually put it together with helpful tips about each piece's location and function.
- Brass: students match instruments and sound.

- Percussion: Students repeat a pattern by clicking on the instruments played in their correct sequence.
- Woodwind: Students guess which instrument is played. Clues and points are given.

At the website of the *Dallas Symphony Orchestra*, students can visit "Families of the Orchestra."[23] Within each section they hear the instrument played alone and then with the orchestra. In the strings section, each instrument plays "Twinkle, Twinkle, Little Star" as a solo, and then with the orchestra. After students have sufficient time to listen, they will identify instruments in the string section with high and low pitches, and loud and soft sounds. They will compare the size of the instrument and the length of its strings to the pitch of the instrument.

Lesson Four: Publishing a Podcast

Objectives: Students will work collaboratively to design a podcast as they examine, synthesize and communicate their understandings of the concepts on the science of sound explored in this unit.

Duration: Two periods (45 minutes each with individual recording sessions)

Procedure:

To begin pulling our thoughts and work together, the students will brainstorm ideas. I will record and display their responses. We will categorize the ideas and sort them by content, curriculum connections, interest, and audience.[24] Students will have opportunity to listen to sample educational Podcasts to give them a better idea of the task at hand.

For this work we will use a variety show format that allows for flexibility in planning segments and is exciting for younger students. We will decide on six segments. Students will work in groups to write scripts for each audio report and create catchy titles. Other students will work with GarageBand to find appropriate sound effects and themed music for background and transitions. Possible segments might include:

- A Word of Welcome: Sound is Everywhere
- Let's Make some Noise
- Word of the Day: Vibrations
- Making Waves
- What's the Matter: What we've learned about how sound travels through states of matter
- Music to Our Ears: Music can be loud or soft, high or low
- Animal Sounds
- Celebrity Interviews: Related careers
- Fun Facts about Sound

As the work evolves, we will use post-it notes on a timeline to order the segments and their time allotments. Each segment will be recorded individually so that the speakers have less distraction and limited outside noise. An outline will facilitate the process of recording. For each segment we will rehearse and then record:

1. Introduction
    - Music
    - Welcome from host
2. Each segment
    - Transition music
    - Introduce segment and speaker
    - Content
    - Transition
3. Closing
    - Closing remarks from Host
    - Credits
    - Music

I will work with a few students to do final editing and preparation for publishing. Students will need a permission form from their parents. When the podcast is completed, it will be uploaded to the School District of Philadelphia's web server. Once that is complete, we will create posters inviting listeners and welcoming their feedback.

Teacher Resources

Asimov, Issac. "Now Hear This" in *Asimov on Physics.* New York: Doubleday, 1976. This article gives a good foundation for understanding how the study of the science of sound evolved.

Backus, John. *The Acoustical Foundations of Music*. New York: W.W. Norton, 1969. The book begins with a solid foundation for learning about acoustics and the physics of sound. This is followed by the physics of music and musical Instruments.

Henderson, Tom. *The Physics Classroom*. 2004 (http://www.physicsclassroom.com) This is an online interactive tutorial of basic physics concepts providing background for the teacher and illusions to use with students.

Issacs, April. *Characteristics and Behaviors of Waves*. New York: Rosen Publishing Group, 2005. Both student and teacher can use this text. It provides a solid basis for understanding wave behavior. The illustrations and captions can be beneficial to students.

Robert Romer. "Physics on the Bus: How About Physics on *Your* Bus?" *Physics Teacher* (Vol. 44. December 2004.) This article provides rationale and procedures for motivating students to illustrate and advertise scientific concepts in ways that are popular on public transportation.

Student Resources

Books for Independent Reading

Beech, Linda Ward. *Magic School Bus in the Haunted Museum: A Book about Sound.* New York: Scholastic, 1995. Introduces or reinforces concepts in an entertaining format.

Catherall, Ed. *Exploring Sound*. New York: Steck-Vaughn, 1990. Explores the many aspects of sound, including how it travels, is received by the human ear, and can be recorded.

Cooper, Jason. *Sound.* Florida: The Rourke Corporation, 1992. Provides a simple discussion of sound waves, frequencies, and the uses of radar and sonar

Dixon, Malcolm and Karen Smith. *Sound and Music*. Minnesota: Smart Apple Media, 1999. In this book the authors explain the production of sounds and music giving simple experiments to illustrate the principles described.

Gibson, Gary. *Hearing Sound.* Connecticut: Copper Beech Books, 1994. Provides step-by-step guide to experiments with sound and hearing. Its colorful illustrations make it very appealing.

Hausherr, Rosemarie. *What Instrument Is This?* New York: Scholastic,1992. Identifies an array of popular musical instruments in a question-and-answer format and discusses how instruments are made, how they sound, and the styles of music for which they are best suited

Jackson, Dorothy and Sally Nankivell-Aston. *Science Experiments with Sound*. Chicago: Franklin Watts, 2000. Explores the properties of sound through experiments. The materials used are readily available.

Kaner, Etta. *Sound Science*. New York: Addison-Wesley, 1991. Explores the nature of sound through experiments and interesting facts.

Issacs, April. *Characteristics and Behaviors of Waves: Understanding Sound and Electromagnetic Waves*. New York: Rosen Publishing Group, 2005.

Pfeffer, Wendy. *Sounds All Around Us*. New York: Harper Collins, 1999.
This book makes learning about sound appealing. As it explains how sounds are made and how the purpose they serve for humans and animals.

Tocci, Salvatore. *Experiments with Sound*. New York: Children’s Press, 2001. Provides simple to do and well illustrated experiments to perform in or out of class.

Text Book

Sound Energy. McLean Virginia: K12 Inc., 2005. This book guides students through the study if sound. The text and illustrations are clearly presented. It works well with its corresponding web resources found at http://www.k12.com.

Sound: *Student Activity Book.* Washington, DC: National Science Resources Center, 1997.

Web Resources for Lessons

Carnegie Hall Listening Adventure: http://www.carnegiehall.org/article/explore_and_learn/art_online_resources_listening_adventures.html. At this site students can learn about sound and instruments in a fun, interactive exploration of musical selections.

DSOKids. Dallas Symphony Association
http://www.dsokids.com/2001/instrumentchart.htm
This site provides attractive and child-friendly resources that introduce students to the orchestra and its instruments.

The Franklin Institute Science Museum:
http://fi.edu/pieces/dukerich/teacher/lessons/teachbackground1.html.
This site provides background information and resources for teachers as well as information and interactive activities for students.

K12 Online Resource: http://www.k12.com. This site is a companion to the student textbook. It requires a password. However, there are some sample lessons available.

National Grid for Learning
http://www.ngfl-cymru.org.uk/vtc/16022007/sound_loundness/lesson.html
This site provides both online teaching and learning materials for students and teachers.

Playmusic.org at <http://www.playmusic.org/index.html >
The American Symphony League built this site. It introduces students to the orchestra, young composers and musicians; it provides an interactive music environment for students to learn as they play with music.

School for Champions: http://www.school-for-champions.com/senses/hearpitch.htm. This is a free educational website with many resources for understanding the science of sound

Appendices/Standards

- Materials/Resources for Lesson:

- Science Journal Book for reflection, notes and glossary

- Computers for each student,
- Internet Access
- Data Recording Sheets
- Applications: Kidspiration, PowerPoint, Garage Band.
- External Microphone

Pennsylvania Academic Standards for Reading, Writing, Speaking, and Listening

Students will have opportunities to read and understand essential content of informational texts and documents; use, understand and evaluate a variety of media; and use spoken, written, and visual language to accomplish their own purposes

- 1.1 Learning to Read Independently (A, B)
- 1.2 Reading Critically in all Content Areas (A, B, C)
- 1.4 Types of Writing (A, B, C)
- 1.6 Speaking and Listening (A, D, E)
- 1.8 Research (A, B)

Pennsylvania Academic Standards for Science and Technology

Students will use a variety of technological and information resources to gather and synthesize information, and to create and communicate knowledge

- 3.1.4 Unifying Themes (B)
- 3.2.2 inquiry and Design (C)
- 3.4.4 Physical Science, Chemistry and Physics (C)
- 3.6 Technology Education (B)
- 3.7 Technological Devices (C, D, E)
- 3.8 Science, Technology and Human Endeavors (A, C)

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[1] Tom Henderson. "The Nature of a Wave." *The Physics Classroom* at <http://www.physicsclassroom.com/Class/waves/U10L1b.html> accessed March 20, 2007.

[2] April Issacs. *Characteristics and Behaviors of Waves*. New York: Rosen Publishing Group, 2005, 14-16.

[3] "What sound Is That?" *The Franklin Institute Science Museum* at < http://fi.edu/pieces/dukerich/teacher/lessons/teachbackground1.html> accessed on March 20. 2007.

[4] Issacs, 22-25.

[5] Tom Henderson. "The Properties of Waves." *The Physics Classroom* at <http://www.physicsclassroom.com/Class/waves/U10L2a.html >accessed on March 20, 2007.

[6] "The Speed of Sound" at *Wikipedia* <http://en.wikipedia.org/wiki/Speed_of_sound > accessed on March 25, 2007.

[7] Issacs, 25-27

[8]Phil Tulga. "Math, Science and Sound Activities." *Music through the Curriculum* at <http://www.philtulga.com/MSSActivities.html#08> accessed on March 30, 2007.

[9] Ron Kurtus. " Hearing Pitch or Sound Frequencies." *School for Champions* at <http://www.school-for-champions.com/senses/hearpitch.htm> accessed on April 2, 2007.

[10] DSOKids. Dallas Symphony Association, 2006 at <http://www.dsokids.com/2001/rooms/musicroom.asp> accessed on April 24, 2007.

[11]Playmusic.org at <http://www.playmusic.org/index.html > accessed on May 15, 2007.

[12]National Grid for Learning at <http://www.ngfl-cymru.org.uk/vtc/16022007/sound_loundness/lesson.html> accessed on May 14, 2007.

[13] The following sites have animated examples of waves
http://www.coolschool.ca/lor/PH11/unit7/U07L01/compressional.mov (Slinky)

http://www.kettering.edu/~drussell/Demos/waves-intro/waves-intro.html (Stick figures and comparison to longitudinal sound waves in air)

http://www.colorado.edu/physics/2000/waves_particles/stadium_wave.html (Cheerleader conducting stadium wave)

http://www.acoustics.salford.ac.uk/schools/index1.htm (Cartoon version of stadium wave) http://www.youtube.com/watch?v=GePz9cmbMDc (Stadium wave at football game)

[14] Catherine Schmidt-Jones. "Transverse and Longitudinal Waves " at *Connexions* <http://cnx.org/content/m12378/latest> accessed on April 27, 2007. (Gives other examples of demonstrating wave motions with students).

[15] K12 Online Resource at <http://www.k12.com> accessed on May 1, 2007. Our school has an account for teacher and student resources. Some sample lessons are available.

[16] *Sound Energy*. K12Inc: McLean Virginia, 64.

[17] *Sound Energy*. K12Inc: McLean Virginia, 66-69.

[18] "Understanding Vibration and Pitch." *Teachers' Domain* at <http://72.32.11.171/resources/phy03/sci/phys/howmove/collage/index.html> accessed on May 1, 2007. Access to the Teachers' Domain collection of K-12 multimedia resources is free, but registration is required.

[19] "Exploring Pitch." *Sound*: *Student Activity Book*. Washington, DC: National Science Resources Center, 1997, 20.

[20] K12 Online Resource at <http://www.k12.com> accessed on May 1, 2007

[21] "Notes and Tunes." *Emerald Harp Productions* at <http://www.playharp.com/Plucked.swf> accessed on May 1, 2007.

[22] Playmusic.org at <http://www.playmusic.org/stage.html> accessed on May 5, 2007.

[23] DSOKids. Dallas Symphony Association, 2006 at <http://www.dsokids.com/2001/instrumentchart.htm> accessed ob May 4, 2007.

[24] Dan Schmidt. Kidcast: Podcasting in the Classroom. FTP Publishing: Illinois, 2005, 35-40.