OPPS

Operation
Primary Physical Science

Sound and Music

Workshop Leader's Guide

Department of Physics and Astronomy- Louisiana State University

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Workshop Outline

1. **ELICIT: What Do We Know About Sound and Music?**

2. **EXPLORE: Exploring Sound Production by Making Musical Instruments.**
   A. Blowing
   B. Plucking
   C. Striking
   D. Stroking

3. **INQUIRE: What is Sound and How is it Produced?**
   A. Dropping Objects
   B. Visible Vibrations
   C. Swings and Things
   D. Make Sense
   E. Apply

4. **INQUIRE: How Can I Change the Sound of a Material?**
   A. Making Two Things Sound the Same
   B. Space Sounds
   C. Relationship Between Mass and Frequency
   D. Make Sense
   E. Apply

5. **INQUIRE: How Does Sound Travel?**
   A. The String Telephone
   B. Comparing Media
   C. Sounds Through Solids, Liquids, and Gases
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6. **INQUIRE: Is There a Model to Explain Sound Phenomena?**
   A. The Slinky
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   C. Observing Two Pendulum
   D. Observing Interference
   E. Make Sense
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Workshop Outline

7. **INQUIRE: How Do We Hear Sounds?**
   A. The Pin Drop
   B. Improving Your Hearing
   C. Make Sense
   D. Apply

8. **REFLECT: Analyzing Musical Instruments**

9. **ASSESS: What Have We Learned About Sound and Music?**

Workshop Sequence

I. ELICIT

What Do We Know About Sound And Music?

The teachers try to identify musical instruments in a pre-recorded video tape. They then compare their predictions with the actual sound by observing the video tape with both the audio and video turned on.

Play the tape with the audio on and the video off. In small groups, have participants identify which instrument they think is making which sound. After they have had some time to decide, replay with the video on. Did they guess correctly? How far off were their guesses?

II. EXPLORE

Exploring Sound Production by Making Musical Instruments

A wide assortment of materials and objects are available for participants to use in exploring the methods of sound production identified in the previous activity, namely, **blowing**, **plucking, striking**, and **stroking**. There are four parts to this — one for each method of producing sound. Notice that, for each method, there is a separate participant activity sheet. It is suggested that you divide the participants into four groups with each group taking one of the four parts and reporting back to the entire group. Each group should begin by freely exploring ways in which sound is produced by the assigned method. The group will then design, construct, and play a musical instrument that uses this method. As each group works, they should write down any important discoveries as well as any questions that arise.

III. INQUIRE

What is Sound and How is it Produced?

Participants start this inquiry by observing the sounds made when different objects strike a surface. From this inquiry they start to develop the concepts of loudness, pitch, and natural frequency. Definitions of words should come from the participants and should be based on their experience with these materials and the ideas they come to the workshop with. If vibrations cause sound, then sound ought to cause vibrations. This inquiry continues with two indirect methods of observing these vibrations. The inquiry ends with the participants making visible the vibrations that are caused by the musical instrument they made in the Explore section. Participants are given a chance to look at questions that were generated earlier and to develop a method of answering them.

Workshop Sequence

IV. INQUIRE

How Can I Change the Sound of a Material?

How much you do with this question will be determined by how much was done in the EXPLORATION phase of the workshop. If you feel that participants have exhausted their study of this question, you may want simply to review what they did and what they found out. For example, have them demonstrate how they can change the sound of a material.

V. INQUIRE

How Does Sound Travel?

Participants inquire about the transmission of sound through various solids, liquids and gasses. They can test out different variables and observe the effects these have on how sound travels. The inquiry concludes with an attempt at measuring the speed of sound transmission in air.

VI. INQUIRE

Is There a Model to Explain Sound Phenomena?

Up to this point participants have observed much about sound phenomena. These observations may seem to be unrelated. This activity is designed to develop a model that will help explain these observations and can be used to explain future observations. You may want to go back to the pre-sequence activity and remind participants of the role of models in scientific endeavors.

VII. INQUIRE

How Do We Hear Sounds?

Participants inquire about improving the hearing of sounds.

VIII. REFLECT

Analyzing Musical Instruments.

Participants reflect on what they know about sound and apply this to instruments they (or you) have brought to the workshop. If no one brings an instrument, then you can replay the video from the ELICIT activity and analyze how those instruments work.

IX. ASSESS

What Have We Learned About Sound and Music?

The participants will first develop a "Sound and Music" concept map based on what they have done in the workshop up to this point. They will then produce a "Sound Effects Story" based on this concept map and present their story to the rest of the group.

Pre-Sequence Activity

In order to develop the idea of what scientists do when they do science, start off the workshop with a game such as Petals Around A Rose. To play this game start with 6 dice (either already placed on an overhead transparency or use the special overhead projector variety dice that you can purchase). Tell the participants that you are going to start the workshop by playing a dice game. Tell them that you are going to roll the dice and say a number based on that roll, they are to come up with the number before you say it. Also, tell them that the name of the game, Petals Around A Rose, is significant in helping them come up with their answer. Start with 6 dice. Roll them and say the number (the only die that you count are the 3 and the 5, each has a center dot, the rose, and petals - the dots around the center dot. You count only the petals. For a roll of 3, that would be 2 and for a roll of 5 that would be 4. The 1 is missing petals, the 2 is missing the central rose, the 4 is missing the central rose, and the 6 is missing the central rose. Roll the six dice for 4-6 times and if people aren't coming up with the rule, go to 5 dice, then 4, then 3, then 2, then 1. When finished (nearly all will get it by the time you get to 1 die), debrief them on what they did. Bring out the idea that they started with some observations, developed a rule from those observations (the rule had to account for their observations and allow for predictions), maybe revised their rule or rejected it and started all over.

Discuss with them that this is basically what scientists do: they observe, they develop models (rules) to explain these observations, and then they apply these rules to new situations. Discuss with the participants that this is probably the role that teaching science in the elementary school ought to take. That is children should explore (make observations), develop concepts from these explorations (rule or model development), and apply these concepts to new situations. Explain that this is the format of an OPPS module. You may even want to go over the parts of the OPPS module. When finished with this then start the module.

Some Key Ideas

THE CONTEXT OF THESE IDEAS WITHIN THIS OPPS WORKSHOP:
Below are some of the ideas about sound and music that K-3 teachers are likely to develop a better understanding of through participation in this OPPS workshop. It is important to stress that the level of most of these ideas is beyond that expected for grade K-3 students by the national standards. However, If K-3 teachers understand these key ideas, they will be better able to provide appropriate learning experiences that help K-3 students work toward the level of understanding that the national standards specify.

1. Sound is produced by vibrating matter.

All sounds are produced by vibrating matter. The vibrations must be in the range of about 20 cycles per second to about 20,000 cycles per second to be heard by humans.

2. Sound is the propagation of longitudinal waves through matter.

When a tuning fork is struck each arm vibrates back and forth. As one arm of the fork moves out it pushes the air in front of it. The air particles receive energy from the tuning fork and are compressed together. This produces a high pressure region called a compression. As this air collides with other particles of air it causes them to be compressed as well. When the tuning fork arm moves back in the other direction, it creates a low-pressure region called a rarefaction. As neighboring particles of air from a compression rush into this low-pressure region, the rarefaction propagates outward from the tuning fork. As the tuning fork continues to vibrate, alternating regions of compression and rarefaction are produced and propagate outwards through the air in all directions. This is a longitudinal wave. The difference between a longitudinal wave and the other kind of wave (such as a water wave) called a transverse wave can easily be shown with a Slinky. With the Slinky held between two people, a flick of the wrist by one will send a transverse wave down the slinky.

To show a longitudinal wave, one person must pull a small number of coils of the slinky toward one end and then release it. This will also produce a wave that travels down the slinky toward the other end. The air particles, as well as the slinky, do not move from one place to another. They just simply vibrate back and forth. It is the wave that moves not the material vibrating.

Waves can be described by their wavelength, amplitude, and frequency. The wavelength is the distance between any point along a wave and the corresponding point on the next wave. The amplitude is the maximum distance the wave moves from its normal position, and the frequency is how many times a second a specific wave moves from its normal position through a complete back-and-forth cycle. The hertz is the unit used to measure frequency.

3. The speed of sound varies depending on the medium through which it is travelling.

Sound generally travels faster through solids, than through liquids or gases. The denser the material, the greater the speed.

Some Key Ideas (Continued)

4. A variety of different methods is used to cause sound vibrations in musical instruments - striking, plucking, stroking, or blowing.

Usually, musical instruments are grouped into 3 groups: stringed instruments (e.g. piano, guitar, cello, violin), wind instruments (e.g. clarinet, trombone, saxophone, trumpet, organ), and percussion instruments (e.g. drums, cymbals)

5. Pitch (highness or lowness of sound) is related to the frequency of vibrations.

Pitch is related to the number of waves that strike your eardrums each second (frequency), and the way your brain processes this information. Low-pitched sounds send a small number of vibrations to your ear per second, while high-pitched sounds send a larger number of vibrations per second. Humans can generally hear sounds from 20 cycles/second (also called 20 hertz or 20 hz) up to about 20,000 hz. As people grow older, their ability to hear high-pitched sounds diminishes. Sounds below 20 hz are called infrasonic while those above 20,000 hz are called ultrasonic. Bats emit sounds with frequencies of 200,000 hz and use the echoes of these sounds to guide their way!

6. Loudness is related to amplitude of vibrations and the size and/or number of vibrating objects.

Loudness of sound is measured in decibels (db), named after Alexander Graham Bell. The following table shows the relative loudness of common sounds.

Jet Airplane, 100 feet away	140 db
Air raid siren, nearby	125 db
Rock music,amplified	115 db
Vacuum cleaner	75 db
Busy street traffic	70 db
Conservation	65 db
Whisper	20 db
Threshold of hearing	0 db

7. Musical sound has tone (harmonic content, quality).

The fundamental frequency is the lowest frequency produced by a vibrating object. The fundamental frequency, and other vibrational modes of the object with frequencies of whole number multiples of this fundamental are called harmonics. The quality of a sound depends on the number of harmonics (also called overtones) and their intensities. The qualities of stringed instruments depend on the mounting of the strings, the method of getting the strings to vibrate, and the characteristics of the sounding boards. In wind instruments, the pitch of the tone is usually that of the fundamental or one of its overtones. In percussion instruments, the fundamental tone depends on the shape, the elasticity, and sometimes (as in drums) the tension of the surface.

Some Key Ideas (Continued)

8. Resonance is the inducing of vibrations of a natural rate by a vibrating source having the same frequency.

Resonance is exhibited when, for example, a tuning fork is struck and then placed on a table top. The sound gets louder because the tuning fork has induced its vibrations into the table.

Master Materials List

I. Elicit
- VCR
- One musical instrument video tape

II. Explore
II-A. Blowing
- A variety of tubes (glass rods, test tubes, golf tubes, plastic, PVC, garden hose, cardboard tubes, sewer pipes, mailing tubes, and a variety of bottles)
- Some items that can be used to fill the tubes (sand, water, cotton, etc.)
- Rulers

II-B. Plucking
- A variety of strings (such as fishing line, thin wire, rubber bands, etc.)
- Some items to attach the strings to (boards, boxes, jugs, etc.)
- Tongue depressors for bridges
- Screw eyes
- Hammers
- Nails

II-C. Striking
- Materials out of which to make drums, cymbals, and shakers (boxes, cans, balloons, plastic eggs, film cans, etc.)
- Small seeds or BB's for the shakers

II-D. Stroking
- A variety of materials from parts A, B, and C

III. Inquire
III-A. Dropping Objects
- One bag of about ten common objects (e.g. paper clip, nail, ping pong ball, crayon, Styrofoam ball, penny, etc.) for each pair of participants
- Something to use as a divider screen for each group of four participants

III-B. Visible Vibrations
- String
- 4 straws
- Lemon liquid detergent
- 1 Tsp. glycerin
- Shallow baking pan
- Audio tape player ("boom box")
- Laser pen (or flashlight with narrow beam)
- Large tin can with ends removed and edges taped for safety
- Small mirror
- Balloon
- Masking tape
- Tiny plastic beads, small bits of Styrofoam, or grains of rice or sand
- Tuning fork
- Pie pan
- Water

III-C. Swings and Things
- A simple pendulum
- Watch or clock with second hand

III-D. Make Sense
- No materials required for this activity

III-E. Apply
- Items already in use in the workshop

IV. Inquire
IV-A. Making Two Things Sound the Same
- Items already in use in the workshop

IV-B. Space Sounds
- Slinky®
- Styrofoam cups

IV-C. Relationship Between Mass and Frequency
- Balance
- Tuning forks of various frequencies

IV-D. Make Sense
- No materials required for this activity

IV-E. Apply
- Items already in use in the workshop

Master Materials List

V. Inquire

V-A. The String Telephone
For each group of two:
- 2 Styrofoam cups
- Various types of string, wire, thread, etc.
- Paper clips

V-B. Comparing Media
For each group:
- Metal hanger
- String, wire, etc (See materials for "The String Telephone")

V-C. Sounds Through Solids, Liquids, and Gases
- Ziploc® bags
- Water
- Sand

V-D. Sound Through a Vacuum
- Vacuum pump
- Bell jar
- Ticking clock

V-E. How Fast Does Sound Travel?
- Stopwatches
- Something to bang with (e.g. boards, cans)
- Meter sticks or tape measures
- Other things the participants need to measure distance and time

V-F. Make Sense
- No materials required for this activity

V-G. Apply
- Items already in use in the workshop

VI. Inquire

VI-A. The Slinky®
- One Slinky® per group

VI-B. Sound Waves
- One Slinky® per group

VI-C. Observing Two Pendulums
- Washers
- String

VI-D. Observing Interference
- Golf tubes
- Tuning forks
- Container for water

VI-E. Make Sense
- No materials required for this activity

VI-F. Apply
- Rain coat
- Water gun

VII. Inquire

VII-A. The Pin Drop
- Pin (or some other object to drop)
- Meter stick

VII-B. Improving Your Hearing
- Large sheets of paper or thin cardboard (e.g. manila folders)
- Masking tape
- Cans
- Other items already in use in the workshop

VII-C. Make Sense
- No materials required for this activity

VII-D. Apply
- Items already in use in the workshop

VIII. Reflect

- Various musical instruments or video from ELICIT section

IX. Assess

- Any materials used throughout the workshop should be made available to the groups for the production

I. ELICIT What Do We Know About Sound And Music?

GOAL:

To get teachers to discuss what they know, what they think they know, and what they do not know about sound and musical instruments

OVERVIEW:

The teachers try to identify musical instruments in a pre-recorded video tape. They then compare their predictions with the actual sound by observing the video tape with both the audio and video turned on.

Play the tape with the audio on and the video off. In small groups, have participants identify what instrument they think is making what sound. After they have had some time to decide, replay with the video on. Did they guess the correct instruments? How different were the guesses?

MATERIALS:

- One video-tape player
- One musical-instrument-video tape (See "Preparation" below.)

PREPARATION:

Video-tape bands from MTV or other television channels (get as large a variety of instruments as you can). It works best to have a video in which only one instrument is playing at a time. An alternate method would be to use CDs or tapes of music. Peter and the Wolf is a good example of music that would work for this activity.

I. ELICIT Identifying Musical Instruments

Play the tape with the sound on and the video off. In small groups, have participants identify what instrument they think is making what sound. After they have had some time to decide, replay with the video on.

Did they guess the instruments correctly? How accurate were their guesses?

Start developing a flip-chart list of ideas, concepts, and questions that arise not only in this activity, but throughout the workshop. This can be added to as the workshop continues. If you are having the participants keep a journal, this is a good time to discuss with them what you would like to see them include in such a written format.

I.Elicit: Identifying Musical Instruments

1. Listen to the tape, and in your group decide what instruments are making the sounds.

2. How accurate were your predictions?

3. Make a list of any questions that came up that you would like to see answered at some point during this workshop.

I. ELICIT Identifying Musical Instruments

TIME OUT FOR DISCUSSION

Lead a discussion on the methods used to get sound out of the instruments (e.g. blowing, plucking, stroking, and striking). Can participants identify which instruments use which method? Ask participants to explain the reasoning behind their identification. Words such as pitch, loudness, tone, quality, etc. may be used by the participants in describing their observations. Don't be concerned about the accuracy of their usage at this time.

Note: If participants own and/or play a musical instrument, invite them to bring their instrument to the workshop the next time you meet.

II. EXPLORE Exploring Sound Production By Making Musical Instruments

GOAL:

To have teachers explore how sound is produced in musical instruments, and to have them generate a list of questions about sound that they would like to find answers to during the workshop.

OVERVIEW:

A wide assortment of materials and objects is available for participants to use to explore the methods of sound production identified in the previous activity, namely **blowing**, **plucking, striking** , and **stroking**. Notice that for each method, there is a separate participant activity sheet. It is suggested that you divide the participants into four groups, with each group taking one of the four parts and reporting back to all. Each group should begin by freely exploring ways in which sound is produced by the assigned method. The group will then design, construct, and play a musical instrument that uses the method. As the groups work, they should write down any important discoveries, as well as any questions that arise.

You may want to announce a time limit on this exploration. It should be at least an hour. Participants need time to explore the various materials that are available before figuring out how they are going to build their instrument. You may want groups to explore for half the allotted time before making their instrument. Periodically, remind them how much time is left. If groups finish making their instrument and time is left, have them explore the other parts of the activity without making an instrument.

Before participants get started with the activity, talk with them about the kinds of questions you are interested in having them come up with. If a question arises that they can easily answer in their exploration, have them do so. Example: "Will filling this bottle with sand change the way it sounds when I strike it?" This question can be easily answered by doing the activity.

Another example: "Why does a bottle sound the same when I blow in it, no matter whether it is sitting in sand or sitting on the table, but it sounds different if I strike it when it is sitting in the sand than when it is sitting on the table?" This question is not as easily answered by experimenting and is the type of question you want participants to come up with during their explorations.

Your role as leader is critical during the exploration phase. You must go around from group to group, asking them what they are doing and what they are finding out. Also, ask about the questions they are coming up with. Encourage them to answer as many of their own questions as they can.

II. EXPLORE Exploring Sound Production By Making Musical Instruments

MATERIALS:

II-A. Blowing

- A variety of tubes such as metal pipes, glass rods, test tubes, golf tubes, plastic, PVC, garden hose, cardboard tubes, sewer pipes, mailing tubes, and a variety of bottles
- Some items that can be used to fill the tubes, such as sand, water, cotton, etc.
- Rulers

II-B. Plucking

- A variety of strings, such as fishing line, thin wire, rubber bands, etc.
- Some items to attach the strings to, such as boards, boxes, jugs, etc.
- Tongue depressors for bridges
- Screw eyes
- Hammers
- Nails

II-C. Striking

- Materials out of which to make drums, cymbals, and shakers, such as boxes, cans, balloons, plastic eggs, film cans, etc.
- Small seeds or BB's for the shakers

II-D. Stroking

- A variety of materials from parts A, B, and C.

II. EXPLORE Exploring Sound Production By Making Musical Instruments

A. Blowing

Ask participants to find out what they can about how sound is made with these materials as they build their instrument. Have them systematically explore these materials and write down observations made and questions developed as a result of this exploration. NOTE: The tubes may be both sound makers and sound transmitters. Participants may work individually or in small groups. Participants will probably need time to explore the various materials that are available before figuring out how they are going to make their instrument.

Depending on the time you have available, you may want to divide the larger group into four smaller groups, with each group responsible for one of the areas (blowing, plucking, striking, or stroking). Or, you may want all participants to investigate all four of these methods. Whichever you decide, you should make sure that all groups get to do blowing and/or plucking in addition to anything else they do.

The following are suggestions for this exploration. You can even write these up as problem cards, but eventually you will want the participants to come up with their own explorations.

As the exploration develops, you should move about the room, asking leading questions if the participants are struggling with their explorations.

Encourage the development of these questions during this exploration. These are the questions that will serve as part of the basis for the INQUIRE activities.

Give participants plenty of time for this exploration (at least one hour). Make sure they are keeping a log of their discoveries and any questions that come out of this. After some time, stop the exploration and discuss with the participants what they did, what they found out, and what kinds of questions arose from this exploration.

II-A. Explore: Blowing

1. Cap one end of a tube and try to make a sound by blowing across it. What way did you find to make the best sound? Try making a sound without the caps. Try covering the tubes with other materials and continue to make sounds. Compare the sounds made. How can you vary the sound? Try taping some of the tubes together. Now how do they sound? Compare how hard you have to blow with long vs. short tubes. Is it possible to get the same pitch from tubes of different lengths? What effect does the diameter of the tubes have on the sound they make?

2. Are there any tubes that make the same sound? Is it possible to get two tubes of differing lengths to make the same sound? What would happen if you filled tubes of different lengths with water to the same height? Try putting different items, besides water, in the tubes.

3. Order a series of tubes by sound (high pitch to low pitch).

4. Try adding items to your tubes, e.g. funnels, paper funnels, tubes fitting within other tubes, etc. What effect does this have on the sound made? Next, make a musical instrument out of the materials. Describe the type of instrument you made. For example, what way did you find to make the best sound from the instrument? How can you vary the sound? Which instrument in the video is this one most closely related to?

6. What questions does your group have as a result of this exploration? These questions should lead to possible investigations.

7. What kinds of questions come out of this?

Participants generate a list of questions. For example:

1. *What characteristics produce high sounds? Low sounds?*
2. *What makes something loud or soft?*
3. *How can I make music with these sounds?*
4. *Do you get the same results with blowing as with striking?*

II. EXPLORE Exploring Sound Production By Making Musical Instruments

B. Plucking

Ask participants to find out what they can about how sound is made with these materials as they build their instrument. Have them systematically explore these materials and write down observations made and questions developed as a result of this exploration. NOTE: The tubes may be both sound makers and sound transmitters. Participants may work individually or in small groups. Participants will probably need time to explore the various materials that are available before figuring out how they are going to make their instrument.

As the exploration develops you should move about the room asking leading questions if the participants are struggling with their exploration.

Encourage the development of these questions during this exploration. These are the questions that will serve as part of the basis for the Inquire activities.

Give the participants plenty of time for this exploration (at least one hour). Make sure they are keeping a log of their discoveries and any questions that come out of this. After some time, stop the exploration and discuss with the participants what they did, what they found out, and what kinds of questions arose from this exploration.

1. *What string characteristics give high sounds? Low sounds?*
2. *What makes something loud or soft?*
3. *Does the length of the string have something to do with sound?*
4. *What kinds of bows can I make that work?*

II-B. Explore: Plucking

1. Using 1 meter of a material (fishing line, wire, etc.) see how many ways you can make a sound. Use other items in the room if you like.

2. How can you vary the sound? Is it possible to get the same pitch from different lengths? different thickness'? Are there any "strings" that make the same sound? Is it possible to get two strings of differing lengths to make the same sound? What role does tautness play?

3. Order a series of "strings" by sound (high pitch to low pitch).

4. Try adding items to your strings, e.g. a bridge, a box, a jar, What effect do these have on the sound made?

5. Next, make a musical instrument out of the materials. Describe the type of instrument you made. For example, what way did you find to make the best sound from the instrument? How can you vary the sound? To which instrument in the video is this one most closely related to?

6. What questions does your group have as a result of this exploration? These questions should lead to possible investigations.

II. EXPLORE Exploring Sound Production By Making Musical Instruments

C. Striking

Ask participants to find out what they can about how sound is made with these materials as they build their instrument. Have them systematically explore these materials and write down observations made and questions developed as a result of this exploration. NOTE: The tubes may be both sound makers and sound transmitters. Participants may work individually or in small groups. Participants will probably need time to explore the various materials that are available before figuring out how they are going to make their instrument.

As the exploration develops you should move about the room asking leading questions if the participants are struggling with their exploration.

Encourage the development of these questions during this exploration. These are the questions that will serve as part of the basis for the Inquire activities.

Give the participants plenty of time for this exploration (at least one hour). Make sure they are keeping a log of their discoveries and any questions that come out of this. After some time, stop the exploration and discuss with the participants what they did, what they found out, and what kinds of questions arose from this exploration.

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2. *What makes something loud or soft?*
3. *Does the length of the string have something to do with sound?*
4. *What kinds of bows can I make that work?*

II-C. Explore: Striking

1. Stretch rubber sheeting over a box or can. How does the sound compare when you strike it softly as when you strike it hard? Does it matter where you strike it? How does tightening the rubber sheeting change the sound?

2. Make a shaker. A plastic egg with some rice inside works nicely. Try making different sounds with your shaker. Can you muffle the sound? Can you make it loud and soft?

3. Bang two things together. Can you make it sound loud? Soft? What happens if you add something?

4. Next, make a musical instrument out of the materials. Describe the type of instrument you made. For example, what way did you find to make the best sound from the instrument? How can you vary the sound? Which instrument in the video is this one most closely related to?

5. What questions does your group have as a result of this exploration? These questions should lead to possible investigations.

II. EXPLORE Exploring Sound Production By Making Musical Instruments

D. Stroking

Ask participants to find out what they can about how sound is made with these materials as they build their instrument. Have them systematically explore these materials and write down observations made and questions developed as a result of this exploration. NOTE: The tubes may be both sound makers and sound transmitters. Participants may work individually or in small groups. Participants will probably need time to explore the various materials that are available before figuring out how they are going to make their instrument.

As the exploration develops you should move about the room asking leading questions if the participants are struggling with their exploration.

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Give the participants plenty of time for this exploration (at least one hour). Make sure they are keeping a log of their discoveries and any questions that come out of this. After some time, stop the exploration and discuss with the participants what they did, what they found out, and what kinds of questions arose from this exploration.

1. *What string characteristics give high sounds? Low sounds?*
2. *What makes something loud or soft?*
3. *Does the length of the string have something to do with sound?*
4. *What kinds of bows can I make that work?*

II-D. Explore: Stroking

1. Using the objects, see how many ways you can make a sound by stroking. Use other items in the room if you like.

2. How can you vary the sound? Is it possible to get the same pitch from different objects? Are there any objects that make the same sound?

3. Order a series of objects by sound (high pitch to low pitch).

4. Try adding items to your objects e.g. a bridge, a box, a jar, What effect do these have on the sound made?

5. Next, make a musical instrument out of the materials. Describe the type of instrument you made. For example, what way did you find to make the best sound from the instrument? How can you vary the sound? To which instrument in the video is this one most closely related to?

6. What questions does your group have as a result of this exploration? These questions should lead to possible investigations.

II. EXPLORE Exploring Sound Production By Making Musical Instruments

TIME OUT FOR DISCUSSION

Conclude the exploration activity and, after the participants have had time to explore the materials, make a composite list of the questions they came up with. Do this separately for the four different methods. Once this is done, classify all of the questions into the following five categories:

a. How is sound produced?
b. Once I make a sound, how can I change the sound of that material?
c. How does sound travel?
d. How do we hear sounds?

You may want to make up headings ahead of time for the four categories (with "other" as a fifth category). As participants develop questions, they can write them on an index card (one question/ card) and place them under the appropriate category heading. Look at the questions and identify those that can be answered easily. Encourage the participants to try to answer these questions. Questions that are not as easily answered should be addressed later in the workshop.

These next several inquiries form the basis of the conceptual development part of the SOUND AND MUSIC module. We have suggested some activities, but they are, by no means, all that could be done. If your participants have asked questions that are not included here, see if they (and/or you) can come up with a way to investigate their questions.

The INQUIRE part of the workshop is more structured than the previous EXPLORATION section. As this part of the workshop progresses, make sure you take plenty of time to have the participants develop the concepts. Stop from time to time to discuss their observations and their understandings. This can be done with individuals, small groups, or the large group. These understandings can easily be listed on chart paper for future use and for updating as the workshop progresses.

Questions such as "How do you know?" or "What is your evidence?" are very appropriate to be asked throughout.

Each INQUIRE section ends with MAKING SENSE. This is a time to tie together the concepts developed, questions answered, new understandings, etc. If you have ideas for investigations (or demonstrations) that are not listed here, and you think they are appropriate for the audience, by all means use them. Keep in mind, we are investigating sound as well as music. Try to relate the two as much as you can as the participants go through the activities.

III. INQUIRE What Is Sound And How Is It Produced?

GOAL:

To get the participants to inquire about sound and sound production. Another goal is for the participants to investigate their own questions that have not yet been addressed

OVERVIEW:

Participants start this inquiry by observing the sounds made when different objects strike a surface. From this inquiry, they start to develop the concepts of loudness, pitch, and natural frequency. Definitions of words should come from the participants and should be based on their experience with these materials and the ideas that they already have when they enter the workshop. If vibrations cause sound, then sound ought to cause vibrations. This inquiry continues with two indirect methods of observing these vibrations. The inquiry ends with the participants making visible the vibrations that are caused by the musical instrument they made in the Explore section. Participants are given a chance to look at questions that were generated earlier and to develop a method of answering them.

This inquiry contains the following activities:

A. Dropping Objects
B. Visible Vibrations
C. Swings and Things
D. Make Sense
E. Apply

SCIENCE IDEAS

- Sound is produced by vibrating matter.
- Evidence can be presented indicating the presence of vibrations, which can be detected by indirect and direct means.
- It is possible to identify objects by the sound they make when striking a surface.
- Sounds may vary in loudness and in pitch and quality.
- The loudness of a sound is related to the amount of energy used to produce the sound.
- The pitch is determined by the frequency of the vibrations.

III. INQUIRE What Is Sound And How Is It Produced?

MATERIALS:

III-A. Dropping Objects

- One bag of about ten common objects (e.g. paper clip, nail, ping pong ball, crayon, Styrofoam ball, penny, etc.) for each pair of participants
- Something to use as a divider screen for each group of four participants

III-B. Visible Vibrations

- String
- 4 straws
- Lemon liquid detergent
- 1 Tsp. glycerin
- Shallow baking pan
- Audio-tape player ("boom box")
- Laser pen (or flashlight with narrow beam)
- Large tin can with ends removed and edges taped for safety
- Small mirror
- Balloon
- Masking tape
- Tiny plastic beads, small bits of Styrofoam, or grains of rice or sand
- Tuning fork
- Pie pan
- Water

III-C. Swings and Things

- A simple pendulum
- Watch or clock with second hand

III-D. Make Sense

- No materials required for this activity

III-E. Apply

- Items already in use in the workshop

III. INQUIRE What Is Sound And How Is It Produced?

A. Dropping Objects

Participants rank their prediction of the objects in the bag in terms of how loud the sound will be when striking the surface. Ask for their definition of loudness.

The variable could be the type of surface on which the object was dropped or the height from which the object was dropped or other variables from the participants.

You will want to monitor what the objects are being dropped on. You might want each group to drop theirs on a table, or on the floor, or you might want different groups to drop their objects on different surfaces.

You should ask groups to explain any discrepancies between their prediction and the actual result.

As you move around the room, ask them to explain why they made their ranking the way they did. Ask them for their definition of pitch.

Again, ask participants if they can explain any discrepancies between the predicted and the actual results.

This may be difficult to do. It will depend on the objects, how they are dropped, and on what they are dropped.

III-A. INQUIRE: Dropping Objects

Part One

1. Collect one set of materials for your group. They are in the baggies.

2. Design an activity that will allow you to compare the loudness as well as the pitch of these objects as you drop them onto something. Before you actually carry out the experiment, predict a ranking from loudest to softest. On what did you base your prediction? Also, predict a ranking from highest pitch to lowest pitch. On what did you base your prediction?

Loudness prediction: Loudest to softest

Actual loudness ranking:

Pitch Prediction: Highest to lowest

Pitch Ranking

3. Try changing a variable and see what effect that has on your results.

4. Now see if you can use your "dropping objects" to create a song that is recognizable to other groups. Note: if it helps, drop the objects onto surfaces other than the table.

Part Two

1. Sit across a table from another group. Place a posterboard screen between the two groups. Each group should first select one person in their group to be the dropper. The dropper from one group should then take one object from the bag and drop it onto the surface of the table. This is done without the other group seeing what was dropped. The other group should then decide which object has been dropped and hold up one of theirs which match. Do this with several of the objects, then switch by having the other group be the droppers.

2. One group should now select 6 of the objects. The other group should select the same 6 objects. Let each object stand for a letter of the alphabet (e.g. C, E, S, T, O, D). Now each group can try to make up a word from these letters. Keeping the posterboard screen in place, see if the other group can determine the other's word after the objects have been dropped to spell that word. Switch again and have the other group sound out their word.
NOTE: A variation could be to send an entire message.

Review the results. How successful were people in identifying the objects? Which objects did everyone identify and why do you think they did so? Which objects were hard to identify and why? Discuss what it is about sounds that helps us to recognize different objects and materials. Why do some things sound different from others when dropped? Eventually lead participants to the idea that something is vibrating to cause these sounds and that this vibration is a characteristic natural frequency of the object being dropped. Review again their idea of loudness and pitch.

The idea for parts of this activity comes from the SAVI-SELF program, Lawrence Hall of Science, University of California, Berkeley.

III. INQUIRE What Is Sound And How Is It Produced?

A. Dropping Objects (cont.)

TIME-OUT FOR DISCUSSION

Review the results. How successful were people in identifying objects? Which objects could everyone identify and why do you think they did so? Which objects were hard to identify and why? Lead participants to the idea that something was vibrating to cause each of the sounds and the sound varied depending on what was vibrating. In some cases it was the dropped object, in some cases it was the surface on which the object was dropped, and in some cases it was both of these. Why do some objects sound different from others when dropped? Draw out the idea that the sound produced depends on the object being dropped, how it is dropped, and on what it is dropped. What is it about the sounds that helps us to recognize different objects and materials? Expect participants to identify differences in pitch and loudness. Discuss that there are actually three characteristics of sound:

1. pitch
2. loudness
3. quality

Discuss with participants how this third characteristic, which will be examined more closely later in the workshop, relates to the unique properties of the sound maker. It is what allows us to tell the difference between middle C played by a violin and middle C played with exactly the same loudness by a trumpet. It is what lets us recognize the voices of our friends, even over the telephone. It is what allows a trained ear to appreciate the difference between music played on a Stradivarius violin versus music played on an inexpensive model.

III. INQUIRE What Is Sound And How Is It Produced?

B. Visible Vibrations

The following demonstrations illustrate different ways of making vibrations visible. You should conduct at least two, if not all three, since the demonstrations will give participants ideas that they may be able to modify for use in the next activity. You may want to do these as leader-led demonstrations, or assign each activity to a different group to conduct and demonstrate in front of the larger group.

Once all of the demos have been conducted, give groups time to discuss their observations and make some generalizations based upon what they have seen. These might include

1. *Sound vibrations can be detected and made visible by indirect means.*
2. *Sound is louder when vibrations are larger.*
3. *When vibrations are faster (more rapid), the sound has a higher pitch.*

***SPECIAL NOTE**: Items #2 and #3 above are ideas that many teachers in the OPPS field test workshops failed to grasp. Please take extra time to develop and discuss these important ideas.*

The dot should vibrate in a regular fashion. The vibrations will also probably be much more apparent.

Participants should see some very fast vibrations that almost immediately disappear.

III-B. INQUIRE: Visible Vibrations

It is often difficult to see that an object or material that is making a sound is vibrating. The following demonstrations, all of which are suitable to use with children, make these vibrations visible. Observe as your workshop leader conducts one or more of them.

1. The Bubble Machine

Materials:
- String
- 4 straws
- Lemon liquid detergent
- 1 Tsp. glycerin
- Shallow baking pan
- Audio tape player ("boom box")

Make some soap bubble solution by mixing four parts of water with one part of lemon liquid dishwashing detergent and adding one teaspoon of glycerin. Pour the solution into the baking pan.

Make a bubble blowing frame by running a long string of about 4 straw lengths through 4 straws and tying the ends of the string together. Dip the frame into the bubble solution until a soap film forms.

Hold the frame so the soap film hangs vertically just in front of the loudspeaker of a tape player that is playing loud music.

What do you observe? How do changes in the music affect the soap film?

2. Dancing Beads

Materials:
- Radio or tape player with exposed speaker
- Tiny plastic beads, small bits of Styrofoam, or grains of rice or sand

Lay the radio or tape player down so that the speaker faces upward. Turn the radio or tape player on. Put a few beads (or grains) on the speaker. Turn the volume up. If possible, change the treble/ bass setting

What do you observe? How do changes in the sound coming from the speaker affect the beads (or grains)?

3. Laser Pen Vibrations

Materials:
- Laser pen (or flashlight with narrow beam)
- Large tin can with ends removed and edges taped for safety
- Small mirror
- Balloon
- Masking tape
- Radio ("boom box")

Place a tightly stretched rubber balloon across one end of the can and secure it with masking tape. This may take a couple of people. Attach the small mirror to the middle of this balloon on the outside of the can. Aim the laser pen at this mirror and have it reflect back to a screen. You may need to attach the laser or flashlight to something to keep it stationary.

Have someone talk into the open end of the can and observe what happens to the dot of red light. Try making different sounds.

Aim the boom box, with some loud music, and a good bass beat, into the open end of the can. How does the red light behave now?

What happens to the red dot if a heavy book is dropped nearby?

*You may find it important at this time to introduce the term **frequency**. It is suggested that it be described as "rate of vibration expressed in terms of vibrations per second." The unit hertz may also be introduced. Remember that once new science terms are introduced in a workshop, they should be continually used and reinforced throughout the remainder of the workshop to allow participants to establish a comfort level with them.*

III. INQUIRE What Is Sound And How Is It Produced?

B. Visible Vibrations (cont.)

No comments.

III-B. INQUIRE: Visible Vibrations

4. Bouncing Ball

Materials:
- Ping pong ball
- Glue
- Tuning Fork
- String

Use glue to suspend the ping pong ball from the string. Strike the tuning fork and touch one side of it to the hanging ping pong ball. What do you observe?

5. Water Waves

Materials:
Tuning fork
Pie pan
Water

Fill the pie pan about half full of water. Strike the tuning fork.

III. INQUIRE What Is Sound And How Is It Produced?

C. Swings and Things

Any kind of pendulum can be used for this activity, from a rubber stopper hanging from a string to a participant sitting in a swing on a playground. A playground swing, if its length can be changed, makes a particularly effective impression and is lots of fun to use when the the weather is nice.

This very simple activity (which could also be conducted as a demonstration) uses a pendulum as a visual model to define frequency, to introduce the idea of natural frequency, and to briefly discuss the limited range of human audibility.

Provide participants with either a model or some basic instructions for setting up a pendulum. Or you may want to have pendulums already set up for the groups.

Allow groups to explore freely, to discuss, to try out their ideas, and to draw conclusions. Expect to take 15-20 minutes.

III-C. INQUIRE: Swings and Things

1. Use the materials provided to make a simple pendulum. Observe the pendulum as it vibrates back and forth. Then discuss and try to answer the following questions:

If the pendulum is vibrating, why doesn't it make a sound?
How would you "measure" the rate at which the pendulum vibrates?
Is the rate of vibration of the pendulum constant?
What can you do to change the rate of vibration of the pendulum?

2. Does this activity give you any new ideas about how vibrating objects produce sound? Write these ideas down. Also, record any new questions about sound that you may have as a result of this activity.

3. Share your ideas and questions in a large group discussion. Be sure to write down any new ideas that emerge during the discussion.

III. INQUIRE What Is Sound And How Is It Produced?

C. Swings and Things

TIME-OUT FOR DISCUSSION

Let groups share their responses to the above questions. Be sure to draw out, demonstrate, or explain the following:

- We can't hear the pendulum because it is not vibrating rapidly enough.
- The range of audibility for humans is between 20 vibrations per second and 20,000 vibrations per second (although not everyone can hear over that entire range). We will learn more about this later when we investigate hearing.
- The rate of vibration is typically described by the frequency (the number of complete back-and-forth vibrations that occur each second) or the period (the number of seconds per complete vibration).
- The frequency is the reciprocal of the period.
- The unit for frequency is the hertz. (Discuss how you would actually measure the frequency or the period of the vibrating pendulum.)
- A pendulum of fixed length always vibrates at the same rate, or has a constant frequency. We call this the "natural frequency" of the pendulum. Even changes in the size of the vibration, or the amplitude, do not alter the frequency. (Show this by demonstration.)
- Almost all objects have a natural frequency at which they vibrate. This is why you can identify a dropped object; it always vibrates with the same frequency and produces a sound with the same pitch. Actually, most objects have more than one natural frequency. (You might use a straw whistle to demonstrate how, depending simply on the way you blow into it, you can produce a lower pitch and a higher pitch.)
- The natural frequencies of an object are all whole-number multiples of its predominant natural frequency. (Thus, if the predominant natural frequency of an object is 220 hertz, other natural frequencies would be 440 hertz, 660 hertz, 880 hertz, etc.)
- Changing the length of the pendulum will change the frequency. A longer pendulum vibrates more slowly, or has a lower frequency, than a shorter pendulum.

III. INQUIRE What Is Sound And How Is It Produced?

D. Make Sense

Urge teachers to try and resolve any disagreements or uncertainties that members of their group may have. They may do this through discussion or additional experimentation. If uncertainties still remain, it is incumbent on you, as workshop leader, to use your judgment as to how best to address them.

Expect that different groups will come up with very similar lists of ideas, although the wording of the ideas may be very different. This is why it is important for you to lead a discussion to develop a consensus list of ideas. Make sure that any ideas that you post on a consensus list are written using language with which the participants are comfortable. You may find that this is a good time to introduce any science terms commonly used to label the ideas the participants have developed.

Also, as each new idea is identified, ask participants for evidence to support the idea. You may want to do the consensus in a two-column format, listing IDEAS (or "What We Know") in the left-hand column and the corresponding EVIDENCE (or "How We Know") in the right-hand column.

III-D. INQUIRE: Make Sense

1. Based on the activities you have just completed, how would you now answer the question that is the focus of this inquiry, "What is sound and how is it produced?" Share and discuss ideas within your group.

2. Revisit your list of IDEAS ABOUT SOUND AND MUSIC and add or make revisions to this list. Make sure that everyone in your group is in agreement about any ideas which are added.

3. Revisit your group's list of QUESTIONS ABOUT SOUND AND MUSIC. Have any of your questions been answered through this inquiry? Have any new questions arisen? Add any new questions to your list.

III. INQUIRE What Is Sound And How Is It Produced?

E. Apply

Have participants go back to their musical instrument built in the Explore section of the workshop. Have them determine what part of the instrument was vibrating to make the sound and demonstrate how they know.

III-E. APPLY

What part of the musical instrument you made earlier in the workshop is vibrating? How do you know? Prove to the other participants what is vibrating.

IV. INQUIRE How Can I Change The Sound Of A Material?

GOAL:

To have participants demonstrate how they can change the sound that an object makes

OVERVIEW:

How much you do with this question will be determined by how much was done in the EXPLORE phase of the workshop. If you feel that participants have exhausted their study of this question, you may simply want to review what they did and what they discovered. For example, have them demonstrate how they can change the sound of a material.

This inquiry contains the following activities:

A. Making Two Things Sound the Same
B. Space Sounds
C. Relationship Between Mass and Frequency
D. Make Sense
E. Apply: Palm Pipes - "Handy Musical Instruments"

SCIENCE IDEAS

- It is possible to change the sound a material makes by altering different variables, such as size, shape, and mass.
- Humans can recognize changes in the pitch, loudness, and tone (quality) of a sound.
- Increasing the energy used to make an object vibrate increases the loudness of the sound produced.

MATERIALS:

IV-A. Making Two Things Sound the Same

- Items already in use in the workshop

IV-B. Space Sounds

- Slinky®
- Styrofoam cups

IV-C. Relationship Between Mass and Frequency

- Balance
- Tuning forks of various frequencies

IV-D. Make Sense

- No materials required for this activity

IV-E. Apply

- Items already in use in the workshop

IV. INQUIRE How Can I Change The Sound Of A Material?

A. Making Two Things Sound The Same

The participants are to apply the concepts developed up to this point by having two somewhat similar items make the same sound.

You may want to suggest some things (e.g. popsicle sticks and tongue depressors, straws and bottles, rubber bands and monofilament, etc). You can instruct the group to brainstorm some possibilities and then either assign them to the participants from the list or let the participants choose their own from the list.

Participants choose a couple of somewhat similar objects and try to get them to make the same sound by varying some feature of one or both objects.

Center some of the discussion on what it means to have two things sound alike. Different people may come up with different ideas on this (e.g. pitch, loudness).

Most will probably say that the pitch of the sound makers is the feature used, but some may choose loudness instead. In any case, make sure you ask for their reasoning.

IV-A. INQUIRE: Making Two Things Sound the Same.

1. Work with a partner. Get two different items from the EXPLORATION activities. Your task is to make these two items sound the same.

2. Briefly discuss what you did to make your two items sound the same.

3 What feature of sound is allowing you to make this comparison?

4. Make any measurements you can to find out what you can do to make two objects sound the same, and that will allow you to compare and contrast the sounds produced. What characteristic(s) do you have to alter to make the sounds the same? Can you generalize?

IV. INQUIRE How Can I Change The Sound Of A Material?

B. Space Sounds

This is a fairly open inquiry in which the participants come up with ways of making "space sounds" using the materials provided. Similar devices can be purchased in many toy stores. The activity, at first glance, may not seem to have much "meat," but it sets the stage nicely for initiating a discussion about the relationship between the physical characteristics of a sound maker and the characteristics of the sound it produces, which is the focus of the next activity.

This activity also provides a good example of ***resonance****, and allows you to introduce this important phenomenon.*

Allow the participants 20-30 minutes to complete their investigations. Afterwards, ask groups to volunteer to share or demonstrate what they have discovered.

IV-B. INQUIRE: Space Sounds

1. As a group, investigate the different ways you can get a slinky to make sounds. Here are some questions to consider:
   - How many different sounds can we make with a slinky?
   - What role do the cups play?
   - What are some other variables that might be investigated?

2. Keep careful track of what you do and what you find out. Be prepared to discuss your findings with the larger group. Set up a data chart below that will make it easy for you to report your results.

DATA CHART

IV. INQUIRE How Can I Change The Sound Of A Material?

B. Space Sounds

TIME OUT FOR DISCUSSION

Groups should discover that the cups can be used to make the sound louder. This can be done by using the cup to direct more of the sound energy to the ear of the listener. It can also be done by using the cup to produce resonance. Point out how the vibrating slinky may cause the attached cup and the air inside the cup to begin vibrating also, increasing the loudness of the sound. Discuss with the participants that this is an example of **resonance**. If time permits, let the participants see and hear other examples of resonance, such as

- touching the stem of a vibrating tuning fork to a tabletop;
- having participants place their hand on the top of their head as they make the "eeeee" sound, and then place their chin on their chest as they make the "uhhhh" sound.

You may also want to discuss how resonance can enhance the quality of the sound.

Culminate the discussion by asking participants to brainstorm examples of musical instruments (pianos, guitars, drums, etc.) that use resonance to amplify sounds.

Another thing all groups should have noticed when investigating the Slinky® is that stretching the Slinky® changes the pitch. Make a note of whether all groups report the pitch changing in the same direction when the Slinky® is stretched. Point out, if the participants have not already noted, that when the Slinky® is stretched, it changes in length, tautness, and weight per unit length (or density). This poses a problem for us as scientists because we are changing not one, but three different variables. Ask participants how we can determine what effect each of these has on the sound produced. Can we design a "fair test" to answer this question? Is it possible to isolate each of these variables?

Suggest that participants think about musical instruments or other sound makers with which they are familiar that make use of changes in only one of these factors. You might want to list these in three categories (length, tautness, weight/ length) on the board or overhead as participants identify them. Once enough examples are posted, ask participants whether we can generalize about the effects of changing length? Of changing tautness? Of changing weight per unit length?

If all strings under consideration are made of the same material, then you could use "thickness" instead of weight/length. You may want to discuss with teachers that many elementary/ middle school texts state that three ways to change the pitch of a vibrating string are to change its ***length***, ***tautness,*** and ***thickness***.

IV. INQUIRE How Can I Change The Sound Of A Material?

C. Relationship Between Mass And Frequency

Check with the participants regarding their procedure. Question them on what they are doing.

Have the participants set up any data charts or graphs of their data. If they do not think of graphing as a way of displaying their data, then suggest it to them.

Relate the conclusions drawn to the musical instruments made in the Explore activity.

IV-C. INQUIRE: Relationship Between Mass and Frequency

Directions: Gather evidence to support or disprove the following statement:

"The mass of a tuning fork is directly related to its frequency."

1. Describe your procedure for answering this question.

2. Display any data collected.

3. What are your conclusions?

IV. INQUIRE How Can I Change The Sound Of A Material?

D. Make Sense

Urge teachers to try to resolve any disagreements or uncertainties that members of their group may have. They may do this through discussion or additional experimentation. If uncertainties still remain, it is incumbent on you, as workshop leader, to use your judgment as to how best to address them. Additional activities, leader-led demonstrations, or summary discussion may be needed.

Expect that different groups will come up with very similar lists of ideas, although the wording of the ideas may be very different. This is why it is important for you to lead a discussion to develop a consensus list of ideas. Make sure that any ideas that you post on a consensus list are written using language with which the participants are comfortable. You may find that this is a good time to introduce any science terms commonly used to label the ideas the participants have developed.

Also, as each new idea is identified, ask participants for evidence to support the idea. You may want to do the consensus in a two-column format, listing IDEAS (or "What We Know") in the left-hand column and the corresponding EVIDENCE (or "How We Know") in the right-hand column.

IV-D. INQUIRE: Make Sense

1. Based on the activities you have just completed, how would you now answer the question that is the focus of this inquiry? Share and discuss ideas within your group.

2. What new important ideas have emerged through this inquiry? Revisit your list of IDEAS ABOUT SOUND AND MUSIC and add or make revisions to this list. Make sure that everyone in your group is in agreement about any ideas which are added.

3. Revisit your group's list of QUESTIONS ABOUT SOUND AND MUSIC. Have any of your questions been answered through this inquiry? Have any new questions arisen? Add any new questions to your list.

IV. INQUIRE How Can I Change The Sound Of A Material?

E. Apply: Palm Pipes - "Handy Musical Instruments"

GOAL:

To allow the teachers to apply ideas of pitch, amplitude, and tone and to link them to sound vibrations and waves in the production of music

OVERVIEW:

Teachers investigate the sound produced by pieces of PVC pipe cut into particular predetermined lengths. They compare these sounds in terms of pitch, amplitude, and tone. They then share their findings and relate these to the key concepts about sound and music that are involved.

MATERIALS:

- Straws
- 1/2 inch cold water PVC pipe cut to the lengths listed below.

Note	Length (cm)	Frequency (Hertz)
F	23.6	349
G	21.0	392
A	18.75	440
B flat	17.5	446
C	15.8	523
D	14.0	587
E	12.5	659
F	11.8	698
G	10.5	748
A	9.4	880
B flat	9.2	892
C	7.9	1046
D	7.0	1174
E	7.25	1318
F	5.9	1397

IV. INQUIRE How Can I Change The Sound Of A Material?

E. Apply: Palm Pipes - “Handy Musical Instruments”

STEP 1

Give each participant a straw and show them how to make a straw instrument. Have them blow into the cut end and describe the sound the straw makes. Have them cut another straw in half (or some other length) and repeat the process of making a straw instrument. How do the sounds compare? You want the participants to realize that there is a difference in pitch when the straws are cut shorter. Longer straws have lower pitches than shorter straws.

Note: If participants have already done this in one of the earlier explorations, then simply review with them the results of that investigation.

STEP 2

Give participants two (or more) of the prepared PVC pipes and ask them to see if they can get these to make a sound. Have them compare the sounds that are produced from the pipes. They may try striking them or blowing on them. Eventually, you would like to have them take the pipe in one hand and hit one open end of it on the palm of their other hand. This technique will generally occur to them if they are given enough time. Have the participants now compare their pipe sounds to others in the workshop. Ask them how the PVC pipes are the same. How are they different? How does the sound produced by one pipe compare with the sound produced by another pipe? From what you know, does this surprise you? Have them compare the generalization about pitch of the PVC pipes to the pitch made in Step 1 with the

STEP 3

Alert everyone to the ideas of pitch, amplitude, and tone. For a striking instrument, such as the palm pipes, pitch can be altered by using a pipe of different length, amplitude can be changed by hitting it harder, and tone can be changed by varying the quality of the striking. See if participants can alter the pitch (which they have already done), amplitude, and tone of the palm pipes. Have individuals share what they have done.

STEP 4

Have the participants think about how these ideas of sound can be applied to the development of music. Have them compare with the straw instrument made earlier. See if any of them can come up with the idea of relating the sound produced by a pipe to a particular musical note.

STEP 5

Ask participants how these different pitches can be applied to the making of music. (Different lengths might produce different notes.) Tell the participants that you have cut the palm pipes into lengths that relate to particular frequencies (notes). Together, as a group, they are going to play some songs. Have them practice striking the pipe on their palm in unison. Have those labeled A strike their pipe, then those labeled B^b, and so on. Show them the music to “Happy Birthday” on the overhead (see Appendix), and direct them as they play this song.

Happy Birthday

Melody C C D C F E C C D C G F
Harmony A A B B^b B^b A

Melody C C C A F E D
Harmony F C B^b

Melody B^b B^b A F G F
Harmony C A B^b A

F Major Scale: F G A B^b C D E F

IV. INQUIRE How Can I Change The Sound Of A Material?

E. Apply: Palm Pipes - "Handy Musical Instruments"

America - unison

F F G E F G A A B A G F
My Coun-try 'tis of thee Sweet land of Liberty

G F E F
of thee I sing etc.....

C C C C B^b A B^b B^b B^b B^b A G

A B^b A G F A B^b C D B^b A G F

Twinkle -Twinkle Little Star

- Play the melody and harmony lines in unison.
- Bottom and top notes go together

Melody F F C C D D C B^b B^b A A G G F
Harmony C C A A B^b B^b A G G F F E E C

Melody C C B^b B^b A A G
Harmony A A G G F F C

Repeat first line...

God Bless America

Melody F E D E D C G F G A G A B^b D
Harmony A C E E D E F D

Melody B^b A C F G A G F G F E F
Harmony C F E C

Melody E F G C F G A C G A B^b E A B^b C
Harmony C E D F E G C G

Melody D C B^b A G F B^b A G F
Harmony F F E C E F F E C

The Bear Went Over the Mountain

Melody F A A A G A B^b A A G G G F G A F
Harmony C C C D C E E E C C

Melody F A A A G A B^b D D C C B^b G F
Harmony C C C D F E E C A

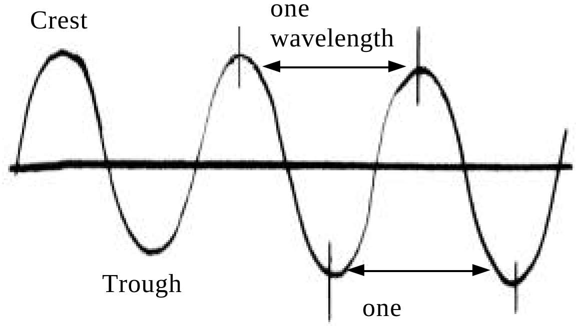
IV. INQUIRE How Can I Change The Sound Of A Material?

E. Apply: Palm Pipes - "Handy Musical Instruments"

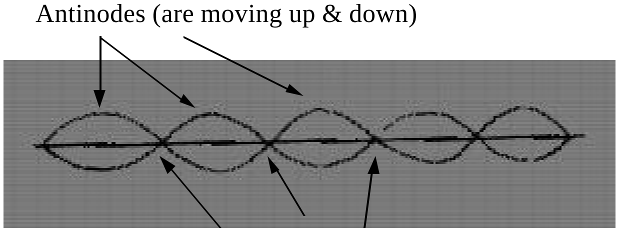
TIME OUT FOR DISCUSSION:

Review with the participants the concepts involved in getting the palm pipes to produce a particular note.

The pitch of a sound wave depends on the wavelength of the sound.

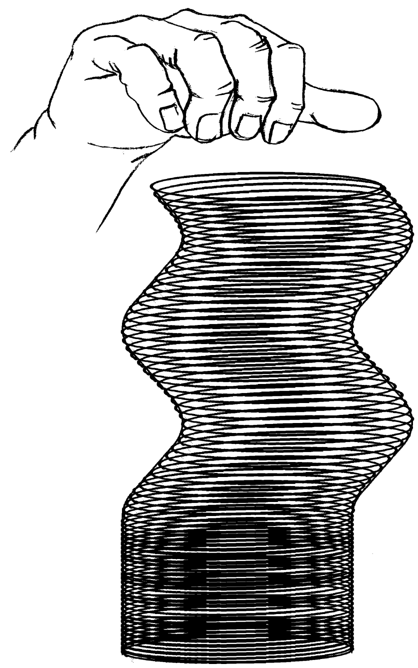


The longer the wavelength, the lower the pitch. Short sound waves produce high pitches. When the pipe hits the palm, many sound waves are sent upward and then echo back down the tube. There they hit other new waves. If the length of the pipe and the length of the sound wave match up perfectly (constructive interference), the echo wave and the new wave will match crest to crest and trough to trough. The waves reinforce themselves and the sound gets louder. This is called resonance. Other lengths of waves don't match up and die out. This is why you hear only one pitch. A different length of pipe will need a different length sound wave to match up. This pipe will produce a different pitch. When resonance occurs, the overlapping waves produce what is called a standing wave.



This has been done earlier in the workshop. The distance from a node to an anti-node is one-fourth of the length of the wave. See if participants can use what they know to understand this sentence. With the palm pipes, how the waves match up depends on how well the air can move at the ends of the pipe. At the end covered by the palm, the air can't move. At the open end, the air can move back and forth. You can think of the sound waves as a Slinky® standing on its end. The bottom of the Slinky® can't move, but the top can.

If you push the Slinky® down and then let it go, the top end will bounce up and down. The bottom end is like the node of a standing wave, the top end like the anti-node. The length of the pipe goes from a node to an anti-node. This is one-fourth the length of the sound wave.



The situation is the same when you blow across the top of the pipe and hold the pipe bottom against the palm.

(This activity was submitted by Gene Easter, William Reitz, and Walter Smith.)

V. INQUIRE How Does Sound Travel?

GOAL:

To develop the idea about how sound travels from its source to where it can be detected; this establishes the idea that sound travels through a medium.

OVERVIEW:

Participants inquire about the transmission of sound through a variety of materials, including various solids, liquids, and gasses. They can test out different variables and the effects these have on how sound travels. The inquiry concludes with an attempt at measuring the speed of sound transmission in air.

This inquiry contains the following activities:

A. **The String Telephone**
B. **Comparing Media**
C. **Sounds Through Solids, Liquids, and Gases**
D. **Sound Through a Vacuum**
E. **How Fast Does Sound Travel?**
F. **Make Sense**

SCIENCE IDEAS

- Sound transmission requires a medium.
- Sound travels differently through different media.
- The speed of sound in air can be measured.
- The speed of sound is much slower than the speed of light.

MATERIALS:

V-A. The String Telephone

For each group of two:
- 2 Styrofoam cups
- Various types of string, wire, thread, etc.
- Paper clips

V-B. Comparing Media

For each group:
- Metal hanger
- String, wire, etc. (See materials for "The String Telephone")

V-C. Sounds Through Solids, Liquids, and Gasses

- Ziploc® bags
- Water
- Sand

V-D. Sound Through a Vacuum

- Vacuum pump
- Bell jar
- Ticking clock

V-E. How Fast Does Sound Travel?

- Stopwatches
- Something to bang with (e.g. boards, cans)
- Meter sticks or tape measures
- Other things the participants need to measure distance and time

V-F. Make Sense

- No materials required for this activity

V. INQUIRE How Does Sound Travel?

A. The String Telephone

Most participants will already know how to make a string telephone. If they do not, demonstrate one for them or have one already produced and placed where all can see it.

Make sure that the participants work in groups of two and only with their original string telephone at this time.

V-A. INQUIRE: The String Telephone

1. Using two Styrofoam cups, some string, and paper clips, make a "string telephone".

2. Find somewhere quiet and stretch the string taut. Now try communicating to each other using one cup as a microphone, the other as an earphone. Can you hear each other? How does the sound get from one person to another?

3. Working with other participants, can you make a party line? Does it work? Can you hear each other? Is there a maximum number that can be on the party line and still have it work?

4. Try systematically substituting other materials for the Styrofoam cups and the string. Is there a difference in the sound you hear? What can you attribute this to?

V. INQUIRE How Does Sound Travel?

B. Comparing Media

Participants will bang a coat hanger on a table and describe the sound. They will then tie various materials to the hanger, bang it on the table again, and with their fingers in their ears, describe the sounds they hear.

Make sure that participants understand that it takes vibrations to make a sound. Ask them what is vibrating in this case.

The sound made will be a clunking sound. The sound is generally not very loud or very pleasant.

The sounds are louder and more musically pleasant. The coat hangers sound like chimes now. The sound is conducted directly from the coat hanger through the solid string. More of the sound reaches your ears this way than it does when it travels through the air to your ears.

Results will depend on the actual materials experimented with. Thickness and tautness of conducting materials may be factors, as well as the densities of the conducting materials. Denser media transmit sounds better than less dense media.

V-B. INQUIRE: Comparing Media

1. Tie a string to a metal hanger and bang it on something (edge of desk, etc.). Describe the sound. Compare your description to others. How did the sound get to you?

2. While holding the string in each hand place a finger in your ear and strike again (see drawing). Describe the sound. How does it compare to the previous one? Why?

3. Repeat with other materials (e.g. wire, fishing line, yarn, thread, etc.) Compare the data from the various materials you tested. Record your results and be prepared to share them with the rest of the group.

V. INQUIRE How Does Sound Travel?

C. Sound Through Solids, Liquids, And Gases

Participants utilize one container of water, one of air, and one of a solid to compare the transmission of sound through different media.

If participants have difficulty coming up with a procedure, the one below works well.

Fill Ziploc® bags with equal volumes of air, water, and sand. Lay these on a desk. Have someone place one ear against each bag, in turn, while someone else taps on the underside of the table below the bag. The listener should plug their other ear.

V-C. INQUIRE: Sound Through Solids, Liquids, and Gases	
1. Work with your group to come up with a procedure for comparing the trans-mission of sound through air, through water, and through a solid substance. 2. When finished, report back to the whole group on what you did and what you found out.	

V. INQUIRE How Does Sound Travel?

D. Sound Through A Vacuum

You will probably have to do this as a demonstration.

Suspend an alarm clock from the top of a bell jar, making sure it does not touch any of the solid parts of the bell jar or vacuum pump. Ask the participants to predict what they think will happen as you turn on the vacuum pump and remove the air from the bell jar.

Do the demonstration.

What should happen is that the sound from the ringing alarm clock gets fainter and fainter as the air is removed from the bell jar. You may need to discuss what's going on with the vacuum pump and bell jar. This may be the first time many of the participants have seen this demonstration.

Discuss with the group the importance of the medium through which sound travels.

V-D. INQUIRE: Sound Through a Vacuum

1. Observe the apparatus. Describe your observations below.	2. What is the significance of these observations?

V. INQUIRE How Does Sound Travel?

E. How Fast Does Sound Travel?

Challenge the participants (working in groups) to figure out at what speed sound travels. Let them do whatever they want. The purpose here is to show how difficult it is to accurately measure distance and time in order to calculate speed.

This is difficult and takes some practice. Time required is 1/3 second or less. Pace off at least 100 yards.

You will probably want groups with at least four members. An alternative method is to work with the entire group.

You may want to take some time and discuss the concept of speed. It would probably work best if you can give them some practical applications of speed. At least do a couple of examples of how to determine the speed of something.

Have them convince you and each other that they are able to measure distance and the necessary time. It is very difficult to actually get decent data by methods of measuring some distance and the time it takes to hear the sound e.g. the time between a starting pistol and the smoke seen from that pistol. The distances chosen are usually not sufficiently far enough apart to account for reaction time. Don't be judgmental with their methods if they can explain how they will do it.

V-E. INQUIRE: How Fast Does Sound Travel?

1. List members of the group:

2. The speed of something is given in units such as miles/hour, meters/second, etc. Miles and meters are two units of measuring distance while hours and seconds are two units of measuring time. Speed therefore is measured by determining how far something travels in a given amount of time. (e.g. an object traveling at a speed of 15 meters/second moves 15 meters each and every second.)

3. Describe how you will obtain the values for the distance and time needed to measure the speed of sound.

4. Obtain these values:

Distance =

Time =

Speed of sound =

5. How confident are you in your answer? What are some possible sources of error?

Confidence in accuracy is probably not very high. Participants should see fairly soon that their reaction time is not quick enough to determine the time of sound travel if the distances are fairly short.

About 346 meters/second or 1100 feet/second in air (in water the speed is about 1500 meters/second, and in steel about 5200 meters/second).

V. INQUIRE How Does Sound Travel?

F. Make Sense

Urge teachers to try to resolve any disagreements or uncertainties that members of their group may have. They may do this through discussion or additional experimentation. If uncertainties still remain, it is incumbent on you, as workshop leader, to use your judgment as to how best to address them.

Expect that different groups will come up with very similar lists of ideas, although the wording of the ideas may be very different. This is why it is important for you to lead a discussion to develop a consensus list of ideas. Make sure that any ideas that you post on a consensus list are written using language with which the participants are comfortable. You may find this is a good time to introduce any science terms commonly used to label the ideas the participants have developed.

Also, as each new idea is identified, ask participants for evidence to support the idea. You may want to do the consensus in a two-column format, listing IDEAS (or "What We Know") on the left-hand column and the corresponding EVIDENCE (or "How We Know") on the right-hand column.

V-F. INQUIRE: Make Sense

1. Based on the activities you have just completed, how would you now answer the question that is the focus of this inquiry? Share and discuss ideas within your group.

2. What new important ideas have emerged through this inquiry? Revisit your list of IDEAS ABOUT SOUND AND MUSIC and add or make revisions to this list. Make sure that everyone in your group is in agreement about any ideas which are added.

3. Revisit your group's list of QUESTIONS ABOUT SOUND AND MUSIC. Have any of your questions been answered through this inquiry? Have any new questions arisen? Add any new questions to your list.

VI. INQUIRE Is There A Model To Explain Sound Phenomena?

GOAL:

To investigate various types of waves as demonstrated with a Slinky®.

OVERVIEW:

Up to this point participants have observed a lot of sound phenomenon. These observations may seem to be unrelated. This activity is designed to develop a model that will help explain these observations and can be used to explain future observations. You may want to go back to the pre-sequence activity and remind participants of the role of models in scientific endeavors.

This inquiry contains the following activities:

A. The Slinky®
B. Sound Waves
C. Observing Two Pendulums
D. Observing Interference
E. Make Sense
F. Apply: "The Doppler Effect"

SCIENCE IDEAS

- Sound travels through matter in the form of longitudinal waves.
- The loudness of a sound is related to the amplitude of the sound wave.
- The pitch of a sound is related to the frequency of the sound wave.
- The frequency of a sound wave is inversely proportional to the wavelength (Frequency=Velocity/Wavelength)
- Resonance is caused when one vibrating object causes another object to vibrate.
- Resonance can be used to amplify and enhance the quality of sounds.
- Sound waves can interfere constructively to produce a wave of greater amplitude, or destructively to produce a wave of lesser or zero amplitude.

MATERIALS:

VI-A. The Slinky®

- One Slinky® per group

VI-B. Sound Waves

- One Slinky® per group

VI-C. Observing Two Pendulum

- Washers
- String

VI-D. Observing Interference

- Golf tubes
- Tuning forks
- Container for water

VI-E. Make Sense

- No materials required for this activity

VI-F. Apply "The Doppler Effect"

- Rain coat
- Water gun

VI. INQUIRE Is There A Model To Explain Sound Phenomena?

A. The Slinky®

Review with the participants that speed = distance/time. Since a wave travels its wavelength (distance) during its period (time) the speed of a wave is given by the formula: speed = wavelength/period. But since frequency is 1/period, the wave speed can also be determined by the following formula: ***speed = frequency x wavelength****. It is recommended that you do this activity as a demonstration, with teachers from the larger group assisting in carrying it out. There are a number of concepts about waves that will be important for the group to observe and discuss and, if left to chance, they may not investigate all of these.*

Have the participants investigate the Slinky®. Start this by having two people stretch the Slinky® between them.
Direct one of them to send a pulse (you will probably have to define transverse wave) along the Slinky®. Discuss their observations. What happened? Have them send small pulses and larger ones.

The Slinky® moved up and down and the wave traveled at right angles to this. You can see the Slinky® moving up and down and you can see the wave traveling. The Slinky® itself did not move in the direction of the wave. To show this, you might tie colored bits of yarn to the Slinky® coils.

Again, (after showing them what a longitudinal wave is) you can see the wave moving along the Slinky®. The Slinky® coils are moving back and forth but the Slinky itself is not moving in the direction of the wave. Point out that sound is a longitudinal wave.

A transverse wave vibrates at right angles to the direction of wave propagation while a longitudinal wave vibrates in the same direction as wave propagation. Make sure the participants observe this difference.

VI-A. INQUIRE: The Slinky

1.Observe the transverse wave sent down the slinky. What moved? What didn't move? What is your evidence?

2. Observe the longitudinal wave sent down the slinky. What moved? What didn't move? What is your evidence?

3. What is the difference between a transverse and a longitudinal wave?

4. At this point reflect on the characteristics of waves. Draw a picture of a transverse wave. Label the parts of this wave.

- **wavelength** - the distance between identical points on the waves, e.g. crest of one wave to the crest of the next wave.
- **crest** - the region of upward displacement in a transverse wave
- **trough** - the region of downward displacement in a transverse wave
- **amplitude** - the maximum displacement of a vibrating part of the wave
- **frequency** - the number of waves passing a point per unit of time
- **period** - the time for one complete cycle or vibration
- **reflection** - the return of a wave from a boundary

VI. INQUIRE Is There A Model To Explain Sound Phenomena?

A. The Slinky® (Continued)

With the Slinky® stretched between two participants have both send a transverse wave down the Slinky® . Have them send the wave by first pulling back on one side of the Slinky® and then on the opposite side of the Slinky®. What do they observe when the two waves meet? You may want to measure the amplitude in some fashion so that it becomes obvious that the waves become much larger if they are in phase (crest with crest and trough with trough) and much smaller if the crest of one meets with the trough of the other.

When two waves meet, they pass through each other. If crest meets with crest and trough meets trough, we have what is called constructive interference, making the resultant crest and trough much larger (greater amplitude). If crest meets with trough, they cancel each other out, leaving no amplitude. This is destructive interference. Constructive interference leads to a resultant wave with a greater amplitude than either of the separate waves, while destructive interference leads to a resultant wave with less amplitude than either of the separate waves. You can also try this with tuning forks vibrating at the same frequencies and then at different frequencies. Discuss real-life examples of constructive and destructive interference of sound waves, such as "dead zones" in rooms.

Select two participants to set up standing waves in the Slinky®. Have them develop one, two, three, etc. standing waves. You may need to put an object at node and anti-node. What observations did they make? Where do the nodes occur in relation to the wavelengths? Where is the amplitude the greatest? the least?
A standing wave is produced by the interference of two periodic waves of the same amplitude and wavelength traveling in opposite directions. Show how to get a variety of standing waves by increasing the frequencies.

VI-A. INQUIRE: The Slinky (Cont.)

5. What happens when two waves meet? Crest to crest? Crest to trough?

6. A. Next, investigate standing waves. What observations do you make?

B. Where do the nodes occur in relationship to the wavelengths?

C. Where is the amplitude the greatest? The least? What is your evidence?

D. What has to occur as you increase the number of standing waves?

E. Is there a relationship between the maximum displacement and the wavelength?

7. What changes occur in waves when you make changes in the existing media (make the spring tighter).

The nodes are the places of least movement.

Increase the frequency (move the Slinky® faster).

Amplitude is greatest at the loops and least at the nodes. One can put objects down by the Slinky® and see what parts of the Slinky® knock these over and what parts do not.

VI. INQUIRE Is There A Model To Explain Sound Phenomena?

B. Sound Waves

No comments.

VI-B. INQUIRE: Sound Waves

1. Divide your group into pairs. Let each pair take turns using the slinky to model a sound wave for:

   A. A very loud sound

   B. A very high pitched sound

   C. A sound that is loud and low

   D. A sound that is soft and low

   E. A very loud, high pitched sound

2. Study the two sound waves below:

   A. Which represents the highest pitched sound?

   B. Which represents the loudest sound?

   C. Which sound travels fastest through air?

Compare and discuss your answers with other members of your group.

VI. INQUIRE Is There A Model To Explain Sound Phenomena?

C. Observing Two Pendulums

This activity is IIE1 (from Operation Physics) Sound Module

The second pendulum shakes erratically but never really swings like the second pendulum did in #3.
OPTIONAL: Show video footage of the collapse of the Tacoma-Narrows bridge.

Forced vibrations and resonance are common happenings that amplify sounds. Megaphones, sounding boards of violins, and even the bones and sinuses of the human head help amplify sounds through both forced vibrations and resonance.

An apparatus known as a "resonance tuning fork" would be a meaningful addition at this point. Two identical tuning forks are attached to two wooden boxes. When one is struck, the other will begin to vibrate. Demonstrate this and see if the participants can relate it to the previous activity.

VI-C. INQUIRE: Observing Two Pendulum

1. Tie a string between two supports, such as desks or chairs. Stretch the string tightly.	4. Change the length of one pendulum so that it is not the same as the other. Start one swinging and observe the second. Record your observations.
2. Cut two equal lengths of string and suspend a washer from each stretched string to produce two independent pendulums as shown below.	5. How would you explain your observations?
3. Start one pendulum swinging. While this one is swinging, observe what happens to the second pendulum. Record your observations.	6. How would you relate this activity to the study of sound?

The second pendulum starts swinging with little movement at first, then greater movement after a while.

This will probably require some input from the workshop leader. The main point to emphasize is that one vibrating object has an effect on objects it is in contact with, and on objects with the same natural frequency that it is not in contact with.

You might also ask participants to recall the Memorex™ commercial on television in which Ella Fitzgerald sang a note that shattered a wine glass. Point out that what Ella had to do was match the natural frequency of the glass, causing it to resonate without contact. She also had to sing the note loudly enough (with enough amplitude or energy) to cause the glass to shatter. But this was no problem, since Ella's voice was recorded on a Memorex™ tape and then greatly amplified when played back.

VI. INQUIRE Is There A Model To Explain Sound Phenomena?

D. Observing Interference

Participants have seen constructive and destructive interference, as shown in the Slinky® activity. In this activity, they actually use sound to observe constructive interference.

Give groups of participants golf tubes (cut into 30 cm lengths), water, jars (at least 20 cm deep) for holding the water, and tuning forks (283 - 480 Hz). Have them place the golf tubes in the water and place the tuning fork above this set-up.

They should hear a definite increase in the loudness of the sound at particular positions of the golf tube in the water.

You can hear the sound of the tuning fork.

They probably don't hear much of a difference at all in the sound the tuning fork makes.

They need to look on their tuning fork and read the number of vibrations off it.

Constructive interference. See if they can relate this back to the Slinky®. The air is vibrating in the air column at the same frequency as the tuning fork is vibrating. The two are said to be in resonance.

VI-D. INQUIRE: Observing Interference

1. Arrange your materials as shown in the drawing below.

DRAWING GOES HERE

2. Strike your tuning fork and place it above the golf tube. Describe your observations.

3. Move the still vibrating tuning fork up and down over the golf tube but do not move the tube. Again, describe your observations.

4. Move the golf tube up and down in the water with the vibrating tuning fork held above it. Describe your observations.

5. At what frequency is your tuning fork vibrating? How do you know?

6. Why do you think the sound gets louder at particular positions of the golf tube over the water? What is your evidence?

VI. INQUIRE Is There A Model To Explain Sound Phenomena?

E. Make Sense

Urge teachers to try to resolve any disagreements or uncertainties that members of their group may have. They may do this through discussion or additional experimentation. If uncertainties still remain, it is incumbent on you, as workshop leader, to use your judgment as to how best to address them.

Expect that different groups will come up with very similar lists of ideas, although the wording of the ideas may be very different. This is why it is important for you to lead a discussion to develop a consensus list of ideas. Make sure that any ideas that you post on a consensus list are written using language with which the participants are comfortable. You may find this is a good time to introduce any science terms commonly used to label the ideas the participants have developed.

Also, as each new idea is identified, ask participants for evidence to support the idea. You may want to do the consensus in a two-column format, listing IDEAS (or "What We Know") on the left-hand column and the corresponding EVIDENCE (or "How We Know") on the right-hand column

VI-E. INQUIRE: Make Sense

1. Based on the activities you have just completed, how would you now answer the question that is the focus of this inquiry? Share and discuss ideas within your group.

2. What new important new ideas have emerged through this inquiry? Revisit your list of IDEAS ABOUT SOUND AND MUSIC and add or make revisions to this list. Make sure that everyone in your group is in agreement about any ideas which are added.

3. Revisit your group's list of QUESTIONS ABOUT SOUND AND MUSIC. Have any of your questions been answered through this inquiry? Have any new questions arisen? Add any new questions to your list.

VI. INQUIRE Is There A Model To Explain Sound Phenomena?

F. Apply: The Doppler Effect

GOAL:

To use the wave model to explain the Doppler effect.

OVERVIEW:

Participants may or may not have heard of the Doppler effect. You should record some samples of this, or at least discuss it, so that the participants realize that they have observed the Doppler effect in their lives.

MATERIALS:

- Rain coat
- Water gun

Step 1:

Discuss with the participants what the Doppler Effect is. This can easily be demonstrated with a Styrofoam ball with a whistle implanted inside. Start the whistle blowing and throw the ball around the room. Participants will hear the pitch change as it approaches them, and then change again as it moves away from them.

Step 2:

See if anybody can use the wave model to explain why this is happening. Have them illustrate this if they can. If not, show the following demonstration. Have one participant put on the rain coat. (You might also want to suggest that the volunteer take off his or her shoes, to avoid getting them wet.) You should take the water gun (Super Soaker™) and shoot them in the back as they stand facing away from you. You can continue to shoot them with the water gun at a known frequency. Have the participants observe the sound as it hits the rain coat. Ask if they can use the wave model to explain what they observe. Next, have the person move away from you slowly as you continue to shoot with the same frequency. How has the rate at which the water

Next, have the person in the rain coat move closer (with their back toward you) and continue to shoot them at the same frequency. What do they now observe about the pattern of water hitting the raincoat? See if anyone can use the wave model to explain this. See if anyone can now put together this whole scenario with a wave model to explain the Doppler Effect.

TIME OUT FOR DISCUSSION:

You may want to spend a few minutes talking about the use of the Doppler Effect in other areas. Examples include the blue shift in light when a star is approaching and the red shift when it is moving away, the use of radar that police use in determining the speed of moving vehicles.

(idea for this activity is from Karen Ostlund)

VII. INQUIRE How Do We Hear Sounds?

GOAL:

To develop the role of the human in hearing

OVERVIEW:

Participants inquire about improving the hearing of sounds.

This inquiry contains the following activities:

A. The Pin Drop
B. Improving Your Hearing
C. Make Sense
D. Apply

MATERIALS:

VII-A. The Pin Drop

- Pin (or some other object to drop)
- Meter stick

VII-B. Improving Your Hearing

- Large sheets of paper or thin cardboard (e.g. manila folders)
- Masking tape
- Cans
- Other items already in use in the workshop

VII-C. Make Sense

- No materials required for this activity

VII-D. Apply

- Items already in use in the workshop

VII. INQUIRE How Do We Hear Sounds?

A. The Pin Drop

NOTE: Can you get participants to compare different solids for transmitting sounds and compare these to air? For example, use a ticking clock. What is the greatest distance between you and the clock at which you can still hear it ticking? Then put a wooden dowel rod next to the ticking clock. Can you hear it from a farther distance?

VII-A. INQUIRE: The Pin Drop

1. Assemble your materials and study them. Sitting around your workstation table, have one person drop the pin onto a metal surface. Can everyone hear it?

2. You are now going to make a hearing tester. Find somewhere quiet. Have one person drop a pin from a distance and see if another person (with back turned) can hear it. Measure how far, in meters, this distance is. Make a chart of your results. Try to find the farthest distance a person can hear the pin drop.

3. Collect all the data. If you have time, try another object, or another method of creating a sound and test everyone again. Then discuss the result. Does everyone have the same hearing score? What might account for differences? Is this a fair test? How could it be improved?

VII. INQUIRE How Do We Hear Sounds?

B. Improving Your Hearing

No comments.

VII-B. INQUIRE: Improving Your Hearing

1. Brainstorm ideas for hearing aid devices and draw some designs. Choose one or two that you think will work best and build some prototypes to test. Try to make them in a way which anybody could use. If necessary, use any other materials in the room.

2. How could you test the hearing increase that your devices give. Find a way to compare them with your normal hearing ability.

3. Take your most successful design, the one that most increases hearing ability, and study it. Decide what it is about the design that makes it successful. Now try to improve it by adapting that part of the design, using the same test as before for comparison.

4. Now reflect on everything you have done during this activity. What generalizations about sound traveling can you make? What evidence do you have to support these generalizations?

VII. INQUIRE How Do We Hear Sounds?

C. Make Sense

Urge teachers to try to resolve any disagreements or uncertainties that members of their group may have. They may do this through discussion or additional experimentation. If uncertainties still remain, it is incumbent on you, as workshop leader, to use your judgment as to how best to address them.

Expect that different groups will come up with very similar lists of ideas, although the wording of the ideas may be very different. This is why it is important for you to lead a discussion to develop a consensus list of ideas. Make sure that any ideas that you post on a consensus list are written using language with which the participants are comfortable. You may find this is a good time to introduce any science terms commonly used to label the ideas the participants have developed.

Also, as each new idea is identified, ask participants for evidence to support the idea. You may want to do the consensus in a two-column format, listing IDEAS (or "What We Know") on the left-hand column and the corresponding EVIDENCE (or "How We Know") on the right-hand column.

VII-C. INQUIRE: Making Sense

1. Based on the activities you have just completed, how would you now answer the question that is the focus of this inquiry? Share and discuss ideas within your group.

2. What new important new ideas have emerged through this inquiry? Revisit your list of IDEAS ABOUT SOUND AND MUSIC and add or make revisions to this list. Make sure that everyone in your group is in agreement about any ideas which are added.

3. Revisit your group's list of QUESTIONS ABOUT SOUND AND MUSIC. Have any of your questions been answered through this inquiry? Have any new questions arisen? Add any new questions to your list.

VIII. REFLECT Analyzing Musical Instruments

GOAL:

To apply what has been learned in this workshop to the workings of various musical instruments

OVERVIEW:

Participants reflect on what they know about sound and apply this to instruments they (or you) have brought to the workshop. If no one brings an instrument, you can replay the video from the ELICIT activity and analyze how those instruments worked.

MATERIALS

- Various musical instruments or video from ELICIT section

The REFLECT section is conducted when teachers have completed all of the content learning activities in the OPPS Sound and Music workshop.

Divide the participants into small groups and give each group an instrument (actual or from the ELICIT video). Have the group analyze how they think the instrument works and, using concepts developed through the workshop, explain the workings of their instrument to the rest of the participants.

Your discussion here can focus on some of the concepts that are used in music.

Usually, musical instruments are grouped into 3 groups, stringed instruments (e.g. guitar, cello, violin), wind instruments (e.g. clarinet, trombone, saxophone, trumpet, organ), and percussion instruments (e.g. drums, cymbals).

The qualities of stringed instruments depend on their overtones, which in turn depend on the mounting of the strings, the method of getting the strings to vibrate, and the characteristics of the sounding boards.

In wind instruments, the pitch of the tone is usually that of the fundamental or one of its overtones. Overtones are tones that vibrate at rates that are multiples of the fundamental vibrating frequency.

In percussion instruments, the fundamental tone depends on the shape, the elasticity, and sometimes (as in drums) the tension of the surface.

When this is finished, have teachers revisit for a final time their lists of ideas and questions about Sound and Music. These lists then serve as tools for teachers to self-assess what they have learned during the workshop. In the optional self-assessment, teachers write a personal learning commentary, identifying the new ideas about sound and music that they have learned during the workshop, and providing evidence to support these ideas.

Revive the overall list of questions about sound and music that has been generated over the course of the workshop.

Ask for observations and comments about this list.

1. Have all the questions been answered?
2. Are some still remaining?
3. Can remaining questions be dealt with now, from the experiences teachers have had, or do they need further experiences or information to do this.

If some questions still are not answered, decide on a strategy for dealing with this. It may be simply a question of drawing some existing threads together, or perhaps you can suggest an activity teachers could do later which will shed light on the question.

IX. ASSESS What Have We Learned About Sound And Music?

GOAL:

To determine the participants' understanding of concepts learned regarding sound throughout this workshop.

OVERVIEW:

The participants will first develop a "Sound and Music" concept map based on what they have done in the workshop up to this point. The participants will then produce a "Sound Effects Story" based on this concept map and present their story to the rest of the group.

MATERIALS

- Any materials used throughout the workshop should be made available to the groups for the production

Have the participants develop a concept map for the Sound and Music workshop. Next, have them use materials from the workshop to develop and illustrate a story with sound (sound effects). The sound effects story will then be performed for all participants. Here are the parameters.

1. Use the SOUND AND MUSIC concept map as your guide.

2. Using at least 2 concepts from the concept map, write and provide sound effects for a story you will perform before the larger group. (5-10 minutes to perform, and 1 hour or more to develop) Have each group identify the concepts that they chose to focus on in the story. These need to be written and explained in terms of how they will be used in the story. Write the story on one side of a paper and write the concepts being developed through the story on the reverse side.

4. During the performance, each participant will be challenged to mark on their concept map the concepts on which they think the performance is focused. After each production, teams have 5 minutes to discuss their analysis. Select one person to write how the concept fits the map and have that person place the sticky dot on the larger concept map. For example, the red team will put theirs up, the blue team theirs, etc... The performing team will put theirs up last and they will all be compared. These are then discussed. Does the performing group agree with the analysis of the other participants? Was anything missed? What? Discuss this with the entire group.

5. Which concepts were omitted in the above and why?