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Description: This lesson helps students develop their abilities to think according to the scientific method. In this lesson students will use the following scientific reasoning tools: prediction, testing, and reporting, to explore the vibrational properties of glass and water. In the process of their experiments, the students will become familiar with terminology related to the physics of sound: Frequency (commonly known as pitch), Decibel also known as Amplitude (the loudness or quietness of a sound), and Duration (the length of time a vibration lasts).

Curricular Outcomes: Strand IV: Using Scientific Knowledge in Physical Science; Standard IV.4 Waves and Vibrations: All students will describe sounds and sound waves, measure and describe vibrations and waves, and explain how waves and vibrations transfer energy. This lesson is designed for grades five through eight.

Materials: This lesson is best done in a science lab where there is access to water and five measuring cups, and five tuning forks (one for each group). Five index cards which have the explanation of “Sound waves” printed upon them. All the children will be asked, at least one week in advance of the lesson, to bring a jam, salsa, mustard, relish, or other type of empty and clean jar to class. A variety of sizes and shapes is to be expected. The Introduction to Javanese Gamelan power point slides (these can be uploaded from the CSEAS website), a laptop computer, and a projector.

Getting Ready: Exploring Sound Waves through Movement

Step One

- While the class is still sitting in the front of the room, demonstrate sound vibrations by dipping a vibrating tuning fork into a cup of water – the vibrating fork should displace the water, causing it to splash out of the cup. Divide the class into groups of five students.
- Explain: that just as the water was displaced by the vibrating object (tuning fork), all vibrating objects displace air. Read the following explanation of “Sound waves” from one of the index cards: “First, as the vibrating object moves outward, it *compresses* the surrounding air. Second, the air *expands*, or rushes into the space formerly occupied by the vibrating object, when the object moves inward. Scientists call these compressions and expansions *condensations* and *rarefactions*. The compressions and expansions of the air near the source of the sound also compress and expand the air farther away. In this way a vibrations travels through the air until it weakens or dies away. These vibrations are known as sound waves.” (“Sound’ in *The World Book Encyclopedia*, Vol. 17, pages 488-496, Chicago, 1967).
- Hand each group an index card with the explanation of “Sound waves.” Each group is instructed to create a short (mime) drama of *condensation* and *rarefaction* as it occurs between a vibrating object and the surrounding air.
- Groups present their mime to one another.

Step Two

- After each group has completed the initial task continue by explaining that sound waves take on very specific characteristics based upon the vibrating object that sets them in motion. Frequency=number of waves per second; Decibel or Amplitude=size of the waves; Duration=length of sound waves.

- Challenge the groups to produce a mime that dramatizes a Sound Wave with these particular characteristics. For example: one group can choose to create a wave that has a high frequency, low amplitude, and is very long. While another group might choose to create a sound wave which has a low frequency, high amplitude, and is very short.
- Groups present their waves to the class. If they have done a good job, the class will be able to guess the characteristics of the wave being presented.

Introduction to the Javanese Gamelan (students are back at their tables, with their jars)

- Show the power-point slides 1 through 5 (up to “Gamelan Musical Structure”).
- Have students describe the instruments that they see on slide three. All the instruments are percussion instruments (vibration is created by hitting the instrument with a stick or beater. There are two main types of instruments: metallophones; and two types of gong instruments: sitting and hanging. The smaller sitting gongs are organized in large groups of notes and the bigger ones are organized in smaller groups. The largest hanging gong is at least three feet in diameter.
- Listen to the recording of “Ricik, Ricik” by University of Michigan Gamelan. Ask: Which of the instruments do you think make the lowest pitches (vibrate at the slowest frequency)? Which instruments do you think play the main melody? (Students will most likely choose the instruments with the metal bars because it is obvious that they can play many different pitches). Tell the class that these “barred” instruments play the main gamelan “melody” and that this is called the *balungan*.
- Put up the notation for “Ricik Ricik” and have students follow along with the recording.
- Explain: “We are going to create these *balungan* instruments using glass jars and water. The reason you are in groups of five is because gamelan music uses a pentatonic system of scales.”

Scientific Process

Predict: Ask each group to place their jars in order from the lowest to the highest pitch. Students will do this task based solely upon the visual appearance of each jar.

Test: Each group will then be given a simple metal spoon. Using the spoon, they are to tap each jar and listen to the pitch it makes. This is a test to see if the group’s visual prediction was correct. Groups will report their findings back to the class.

Predict: Ask: “What would happen if we added water to one of the jars? (Start with a quarter cup of water.) Would the pitch get higher or lower?”

Test: Instruct each group to add $\frac{1}{4}$ cup of water to the jar in the middle of their grouping (jar #3). Test the scale again. Does this jar still sound like the middle pitch of the scale, or has it changed?

Report: Share group findings with the rest of the class. At least one group should have a jar where the pitch doesn't change with just a $\frac{1}{4}$ cup of water.

Repeat: Add another $\frac{1}{4}$ cup of water and repeat the steps above.

Application: Give each group plenty of water. Instruct each of the groups to "tune" their glass gamelan. Ideally, the pitches should be an equal distance apart.

Play: Refer back to the notation for "Ricik Ricik." Ask: "What is the lowest pitch in this piece, and what is the highest?" (2 is the lowest and 7 is the highest) Ask: "Which number is missing?" (number four). Instruct each group to label their jars from lowest to highest pitch (as they have tuned them). Assign one student to "conduct" the class by pointing to the numbers on the chart, in time with the recording. Each student in the group must play when their number is pointed to.

Conclusion

- Have each group create their own gamelan piece based upon the structure of "Lancaran Ricik Ricik."
- Have students verbally share what they learned during the session.
- Also have students journal about what they learned.