"Light, Waves and Interference" - A Teacher's Workshop

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Sound Waves and Interference

Background

All waves exhibit interference phenomena, the effects of their passing through one another as they travel. It is easy to see water wave interference as ripples cross each other: in places they have extra high peaks or extra low valleys where individual-wave peaks or valleys cross paths. In other places the water surface may briefly be smooth and flat, where a peak meets a valley and their sum is zero. Water waves and light waves (in fact, all electromagnetic waves from long wave radio through light to x-rays and gamma rays) are transverse waves, exhibiting peaks and valleys as they travel along their paths.

Sound waves are longitudinal pressure waves, in which a volume changes its density (or, equivalently, pressure) as the wave passes through it. In just the same way as the peaks and valleys of a transverse wave combine, pressure waves can combine for increased amplitude or nulling out at a particular point.

Our ears provide an easy means of finding amplitude maxima and minima when sound waves interfere. This activity demonstrates these effects.

Materials

- Cassette or CD player, preferably stereo and adjustable for left-right balance (a "boombox" is ideal).
- Homemade cassette recording of telephone dial tone (multiple sets with minimum duration 15 seconds, or better yet, a single recording of two minutes duration or longer). (Alternative is commercial cassette or CD with single-frequency tone. These are available for setting recording levels [CD → cassette] and setting stereo equalizer levels, and can sometimes be found on CD player lens cleaning disks.)

Procedure

Play the tone through the left or right speaker (only) at a comfortable level so it can be heard around the classroom. Have students walk around the room (they can start by simply circling their desks) listening for changes in sound volume (sound intensity). Explain that sound waves coming from the speaker reflect off various objects in the room. Sometimes the waves add up (interfere constructively) and make a louder sound at a

particular spot. Sometimes they cancel each other out (interfere destructively) and reduce the sound volume at some other spot. Map the room by having individual children stop at a spot where the tone is loud (or faint).

Repeat the experiment, but have the tone coming from both speakers equally. The pattern will be different because two sets of waves are moving through the room, bouncing off of the same objects but at different angles, so that they are able to interfere with each other at different places.

With either one or two speakers active, have the students listen for differences in volume by changing from a standing position to a kneeling position. This demonstrates the three dimensional nature of sound wave propagation.

Extension

Why don't we notice interference when we listen to voice or music from stereo sound systems?

Benchmarks and Standards

A visit to the URL http://www.mcrel.org yielded the following standards and included benchmarks that may be applicable to this activity.

Standard: 12 *Understands motion and the principles that explain it.*
Level I: Primary (Grades K-2) - Knows that vibrating objects produce sound.

Standard: 14 *Understands the nature of scientific knowledge.*
Level I: Primary (Grades K-2) - Knows that scientific investigations generally work the same way in different places and normally produce results that can be duplicated.

Level II: Upper Elementary (Grades 3-5) - Knows that although the same scientific investigation may give slightly different results when it is carried out by different persons, or at different times or places, the general evidence collected from the investigation should be replicable by others.

Standard: 15 *Understands the nature of scientific inquiry.*
Level I: Primary (Grades K-2) - Knows that learning can come from careful observations and simple experiments.

Level II: Upper Elementary (Grades 3-5) - Knows that scientists use different kinds of investigations (e.g., naturalistic observation of things or events, data collection, controlled experiments), depending on the questions they are trying to answer.

Plans and conducts simple investigations (e.g., makes systematic observations, conducts simple experiments to answer questions).

Level III: Middle School/Jr. High (Grades 6-8) - Designs and conducts a scientific investigation (e.g., formulates questions, designs and executes investigations, interprets data, synthesizes evidence into explanations, proposes alternative explanations for observations, critiques explanations and procedures).

Establishes relationships based on evidence and logical argument (e.g., provides causes for effects).

Standard: 16 *Understands the scientific enterprise.*
Level I: Primary (Grades K-2) - Knows that in science it is helpful to work with a team and share findings with others.

Level II: Upper Elementary (Grades 3-5) - Knows that scientists and engineers often work in teams to accomplish a task.