Math-Science Investigations: BoseBUILD Introduction Class

Objective: Introduce the concepts of magnetism and electromagnetism, and demonstrate how they can interact and cause an object to vibrate. Furthermore, demonstrate how vibrations of an object cause pressure waves in the air which our ears interpret as sound. Explore how the changing frequency of the vibrations and pressure waves causes changes in the perceived pitch of the sound. Start to explore the way that speakers take advantage of electromagnetism to reproduce sounds and maximize the audible sound produced by the vibrations.

Time: 45 minutes

Materials: BoseBUILD control panels, power cables, permanent magnets and coils - 1 per 2 students, and one for instructor demonstration.

> **Why BoseBUILD?:** The BoseBUILD Education speaker kits do a great job of breaking down the basic processes of sound recreation (speakers). The basic model, using a magnet and electromagnetic coil, shows students in simple, tactile ways how sound is produced with a speaker. The technology allows students to expand upon their basic understanding through iterative exploration.

Preparation: Familiarize yourself with the BoseBUILD control panel "demo" modes, and ensure that the control panels have the appropriate demo software running.

Pedagogical Notes: This lesson breaks up the class period into several different activities. Starting with a teacher-led discussion and demo, the students then have time to replicate the demo and experiment on their own. Finally, they are given an extension challenge to which they need to find a solution in partners or small groups.

Procedure:

1. Gather students around a table in front of the classroom with the demonstration kit prepared. Ask them not to touch the kits set up around the room just yet. Put the control panel and electromagnet aside, and hold up the permanent magnet. Ask the students what it is, and then what the properties of a magnet are, trying to get them to break down their preexisting knowledge. Ask them each to write down two questions they have about magnets or magnetism. WIthout answering the questions, bring them back together and test the magnet on various metal surfaces nearby, and try to find metal surfaces that it sticks to and others that it doesn't (US coins are not magnetic). Ask if anyone knows what kids of metals stick to a magnet, and then explain that the most common metals that stick to a magnet have iron in them, and are called ferrous metals. You might ask if anyone knows the periodic table symbol for iron (Fe). Explain that steel is a common alloy (mix of metals) made up mostly of iron.
2. Take the coil (unplugged) and tell the students that the metal part is made of copper. Ask if copper is magnetic (no), and prove it by touching it to the magnet. Explain that it's not actually solid copper, but a single strand of copper coiled around many times. It's *insulated*, meaning that there is a plastic coating on it, that keeps the copper from touching itself as it's coiled around. Explain that the two ends of the coil connect back to two different "pins" on the black connector.

3. Making sure that the control panel is on the RED “launch” mode, and the slider is all the way to the left, plug in the coil, place the coil over the magnet, and act as though nothing is supposed to happen. Ask if anyone has a penny, which is copper plated, just to fill time. Act surprised when the copper coil jumps off the top of the magnet, and put it back on. Continue talking as it happens a couple more times, acting increasingly perplexed. Finally, give in and ask the kids to explain what they think is happening and why.
4. Take some guesses, and explain that the control panel is sending a pulse of electricity through the coil, which actually turns the coil into an magnet. Explain that electricity and magnetism are very closely connected, and that when an electrical current flows, a magnetic field is generated. Explain that a magnetic field is what we call the invisible force that causes magnetic things to attract and repel even when they’re not yet touching. Ask why they think the copper wire is wrapped around to form a coil, and not simply a straight piece of wire (makes the magnetic field stronger).
5. Move the slider all the way to the left, and then change to YELLOW (Motion) mode by pressing the button. Put the coil over the magnet, and watch the coil move up and down at 2 Hz (cycles per second), and explain that vibrations or oscillations are measured in Hertz. Ask similar questions about what is going on. Slowly move the slider to the right to speed up the oscillations. Ask the students to guess how fast it’s going at maximum speed (the maximum speed is 20 Hz).
6. Explain that the control panel is like a little computer, and is capable of sending electrical impulses very, very quickly. Ask them to guess how fast (in Hertz) they think the control panel can send impulses. Move the slider back to the left and switch to GREEN (Sound) mode in order to control the vibrations between 20 Hz and 2000 Hz. Slowly move the slider in order to change the pitch. Ask the students to describe what’s happening. Why are they hearing sounds? What is vibrating? What part of the mechanism is moving the air around it? You have just created a very basic speaker.
7. Explain that air molecules are actually pretty tightly packed in all around us, and that when something vibrates, it moves the air molecules around it. Explain that we will talk about the *pressure waves* that are created more in subsequent lessons.
8. Switch to PURPLE (Music mode, skip over BLUE, which is AUX mode) to listen to a song. Ask the students how they think their simple speaker is creating such a complicated sound. How does this sound compare to the simple tone?
9. Split the group up into partners, and give each of them the parts to assemble the basic “speaker” that you just created. Give them 5 minutes to experiment with the various modes on their own. If any students have devices of their own, they can connect them with an AUX cable, and play their own music in BLUE mode.
10. After 5 minutes, give each group two index cards and a 1’ strip of masking tape, and ask them to try to figure out a way to make their “speaker” as loud and clear as possible.
11. With a few minutes left, ask students to dismantle their speakers, recycle their materials, and explain that they will continue to explore sound and speakers over the next few weeks, getting several opportunities to improve upon their speaker design.

Homework: Watch this video about the mechanics of sound