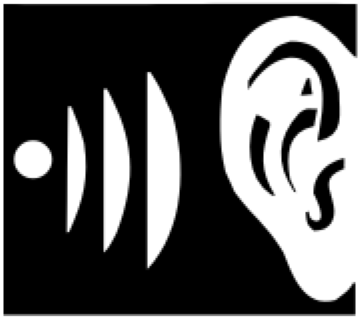
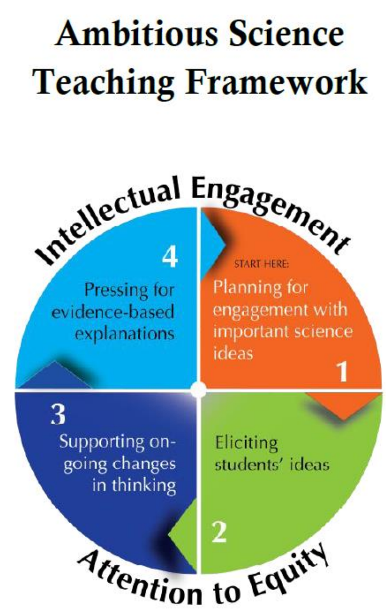


Sound Unit
Grade 4

Contents of this file:

Unit Synopsis:

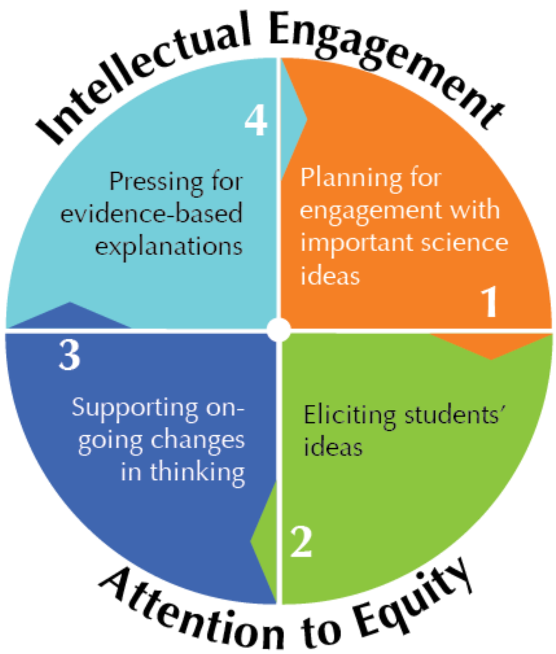
After watching a video clip of a singer shattering a glass with his voice, students gather evidence from a range of activities to explain how the singer is able to do this. The scientific explanation behind this event includes big science ideas around energy transfer and transformation and requires an understanding of the particulate nature of matter to some degree. Throughout the unit, students should have opportunities to create and revise their own models of this glass shattering event in light of new evidence from activities. Ultimately, the model and explanation students create is for the glass-shattering event; however, students should also apply what they understand about sound energy to other phenomenon relevant to their own lives. (Examples may include: loud airplanes flying over their neighborhoods, how guitars or other instruments work, or hearing loud music through walls from their sibling's/neighbor's room.)



Guide created by Carolyn Colley, PhD with input and feedback from 3rd-5th grade teachers and students at Sartori Elementary, Renton Public Schools, ccolley@rentonschools.us

Ambitious Science Teaching

We provide here a vision of ambitious teaching—teaching that is effective, rigorous and equitable. But more than that, we provide a framework of research-based teaching practices that are consistent with this vision and a wide range of tools that can transform how students learn in your classroom. The vision, practice, and tools will furnish a common language about teaching for a group of science educators committed to the improvement of teaching. You will be able to identify "what we will get better at" and how to get started.



Ambitious teaching aims to support students of all racial, ethnic, and social class backgrounds in deeply understanding science ideas, participating in the talk of the discipline, and solving authentic problems. This teaching comes to life through four sets of teaching practices that are used together during units of instruction. These practices are powerful for several reasons. They have consistently been shown through research to support student engagement and learning. They can each be used regularly with any kind of science topic. And finally, because there are only four sets of practices, we can develop tools that help both teachers and students participate in them, anyone familiar with the practices can provide feedback to other educators working with the same basic repertoire, teachers can create productive variations of the practices, and everyone in the science education community can share a common language about the continual improvement of teaching.

The four Ambitious and Equitable Science Teaching Practices are summarized in the below.

Practices	What does it LOOK like?
Planning for engagement with important science ideas	• Planning a unit that connects a topic to a phenomena that it explains (Chemical Reactions – Bike Rusting, Photosynthesis – Seed Becoming a Tree) • Teaching a topic within a real-world context
Eliciting students' ideas	• Asking students to explain HOW and WHY they think a phenomena happens (How did the bike change? Why did it change? What is happening at the unobservable level?)
Supporting on-going changes in thinking	• Using ALL activities/lessons to explain the phenomena. • Giving students opportunities to revise their thinking based on what they're learning
Pressing for evidence-based explanations	• Allowing students to create a final model or explanation about the phenomena • Pressing students to connect evidence to their explanation

Many teachers want to know what their classrooms should look like and sound like—they want to understand how to interact with their students about science ideas and students' ideas. This is especially true now that the *Next Generation Science Standards* are being used in many states. As a result of the last 30 years of classroom research, we know enough about effective instruction to describe in clear terms what kinds of teaching practices have been associated with student engagement and learning. This research tells us that there are many ways that teachers can design and implement effective instruction, but that there are common underlying characteristics to all these examples of teaching that can be analyzed, described, and learned by professionals. These practices embody a new form of "adaptive expertise" that EVERY science educator can work towards. Expert teaching can become the norm, not reserved for a select few. Ambitious teaching is framed in terms of practices that any teacher can learn and get better at over time. What would we see if we entered classroom of a science educator using ambitious teaching? To give you a sense of what ambitious teaching looks like, we have described below some features common to all science classrooms where ambitious teaching is being implemented (listed on right). These features address everyday problems with learning and engagement that teachers face (listed on left).

Common problems in supporting student engagement and learning	**What you'd see in a science classroom where ambitious teaching is the aim**
The problem: *Students don't see how science ideas fit together.* Each day is perceived by students to be the exploration of ideas that are unconnected with previous concepts and experiences.	At the beginning of the unit, students are focused on developing an evidence-based explanation for a complex event, or process. Students know that throughout unit, most of the activities, readings and conversations will contribute to this explanation.
The problem: *An oversimplified view of what it means "to know."* Science ideas perceived to be straightforward and learnable within a lesson—either you get it or you don't."	An idea is never taught once and for all, but revisited multiple times. Students' science explanations are treated as partial understandings that have to be revisited over time to become more refined and coherent.
The problem: *Lack of student engagement.* Students' experiences and interests not elicited or seen as relevant. Student ideas treated as "correct" or "incorrect."	Students' ideas and everyday experiences are elicited and treated as resources for reasoning; students' partial understandings are honored as a place to start. They are made public and built upon.
The problem: *Students reluctant to participate in science conversations.* Teachers dominate the talk, ask primarily for right answers, get brief responses from students.	Teachers use a varied repertoire of discourse moves to facilitate student talk. Guides and scaffolds for talk help students feel comfortable interacting with peers.
The problem: *Some students have little support for accomplishing tasks that would otherwise be within their grasp.* Little or no guidance for students' intellectual work. Giving "clear directions" is seen as enough to ensure participation in activities.	There is scaffolding that allows students to participate in science-specific forms of talk, in group work, and in science practices.
The problem: *Invisibility of student ideas and reasoning.* Teacher does not know what students think—their heads are a black box. Cannot then work on students' ideas. Students cannot take advantage of the ideas or ways of reasoning by their peers.	Students' thinking made visible through various public representations (tentative science models, lists of hypotheses, question they have, etc.). The teacher can see how students think and how that thinking could change over time. Students benefit from seeing and hearing the reasoning of others.
The problem: *Illusion of rigor.* Students reproduce textbook explanations, lean on vocabulary as a substitute for understanding. Talk of evidence and claims are rare.	The teacher presses for complete, gapless explanations for unique real-life events or processes, and press for the use of evidence to support claims.

As you will see, ambitious teaching is not a "method," and the teaching practices are not scripts. It is a set of principled practices that must be adapted to your classroom needs. Coaches and other teachers can work with you to do this ambitious work.

Sound Energy Unit Overview - Grade 4

Waves and Energy Transfer

Phenomenon & Anchoring Question

Jaime Vendera, a singer featured on Mythbusters, can break a wine glass with his voice. Jamie flicks the glass, takes a deep breath, and makes a loud, one-tone sound that shatters the glass, not immediately but after a few seconds of sustained sound. Watch both videos: video of singer and slow-motion glass breaking then ask the question that anchors the unit: **How did the singer break the glass?** Listen and keep track of other examples of sound events students bring up in class, such as, "The lunchroom is so loud, it bothers me," or, "Airplanes fly over my house at night and wake me up." The phenomenon can shift to something more meaningful and problem-based for students as the unit progresses. Start the unit around the breaking glass phenomenon.

Next Generation Science Standards

Below are performance expectations targeted in this unit. The three dimensions—Science and Engineering Practices (SEP), Disciplinary Core Ideas (DCI), and Cross-cutting Concepts (CCC)—should be combined in a variety of ways to support student sensemaking in three-dimensional learning experiences.

- **4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound.** [Assessment Boundary: Assessment does not include quantitative measurements of energy.]
- **4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.** [Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.]
- **4-PS4-3. Generate and compare multiple solutions that use patterns to transfer information.*** [Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.]
- **3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**

Science & Engineering Practices	Disciplinary Core Ideas	Cross-cutting Concepts
Developing and Using Models Use models to describe phenomena. ***Using Mathematics and Computational Thinking*** Measure and graph quantities to address scientific and engineering questions and problems. ***Planning and Carrying Out Investigations*** • Make observations and measurements to produce data to serve as the basis for evidence for an explanation. • Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.	***PS4.A: Wave Properties*** Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. Waves of the same type can differ in amplitude (wave height) and wavelength (space between wave peaks). ***PS4.C: Information Technologies and Instrumentation*** Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. ***ETS1.C: Optimizing The Design Solution*** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	***Cause and Effect*** • Cause and effect relationships are routinely identified and used to explain change. ***Patterns*** • Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena. • Similarities and differences in patterns can be used to sort and classify designed products.

Big Science Ideas

1. **Energy can transfer through matter.**
    a. Matter is made of particles.
    b. Particles can bump into each other to transfer energy.
    c. Energy manifests as sound that we hear or feel decreases over distance as it is transferred through and into matter.

2. **Energy displays or manifests in various phenomena which we describe as “transforming” and this energy is conserved**
    a. Scientists describe energy in many ways, such as: chemical, mechanical, sound, light, heat, electricity based on how we can observe energy (i.e. if we see light, we might say “light energy”). Energy can cause different observable events like light, heat, our sound, but it’s still energy.
    b. For the singer-shattering-the-glass story, mechanical energy is transformed into sound energy and then back to mechanical energy as the energy goes from inside the singer, through the air, and into the glass. Energy is energy is energy; however, calling it by different names can help us more clearly communicate about what we are observing and explaining.

3. **There is a relationship between energy, forces, and matter.**
    a. Sound can make matter vibrate and vibrating objects make* sound.
    b. The stronger the force of the vibration, the louder we hear the sound.
    c. A vibrating object can make another object vibrate.

4. **Sound waves have regular patterns of motion. They can differ in:**
    a. Volume which is represented by the amplitude (height of wave)
    b. Pitch is represented by frequency (how many peaks per second)
    c. Wavelength is the distance between peaks in a wave

* Sound is a way scientists describe energy. Energy is never produced, created, made or conversely destroyed. Energy is only transferred and transformed. Students may use the terms “make” instead of “transform”. Vibrating objects do “produce” sound that we can hear but really the vibrating object is changing how energy “shows up” (observable). The *mechanical* energy (vibrations) “changes” into *sound* by jostling molecules which transfer that energy through the air to our ears.

Clarification for Teachers

What is energy?

Read & discuss this quote:

“The idea that there are different forms of energy, such as thermal energy, mechanical energy, and chemical energy, is misleading, as it implies that the nature of the energy in each of these manifestations is distinct when in fact they all are ultimately, at the atomic scale, some mixture of kinetic energy, stored energy, and radiation. It is likewise misleading to call sound or light a form of energy; they are phenomena that, among their other properties, transfer energy from place to place and between objects.”

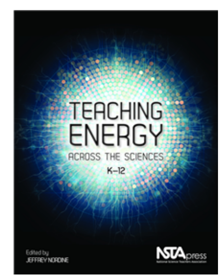
~ A Framework for K-12 Science Education, pg 122

"5 Dimension 3: Disciplinary Core Ideas - Physical Sciences." National Research Council. 2012. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press. doi: 10.17226/13165.

Want more on teaching energy?

Recommended NSTA book: [Teaching Energy Across the Sciences K-12] by Jeffrey Nordine

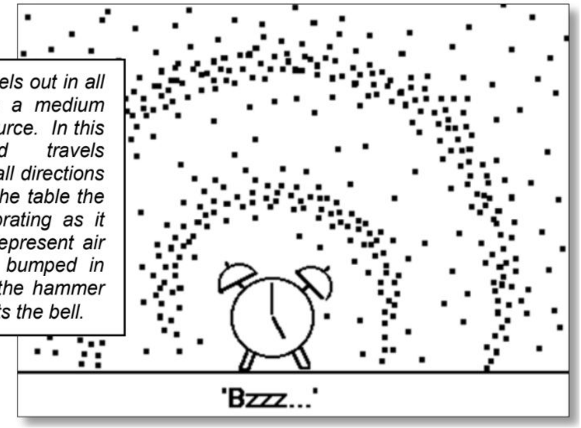
Read [4 pgs Chapter 1] excerpt and discuss [CCC: Energy & Matter].

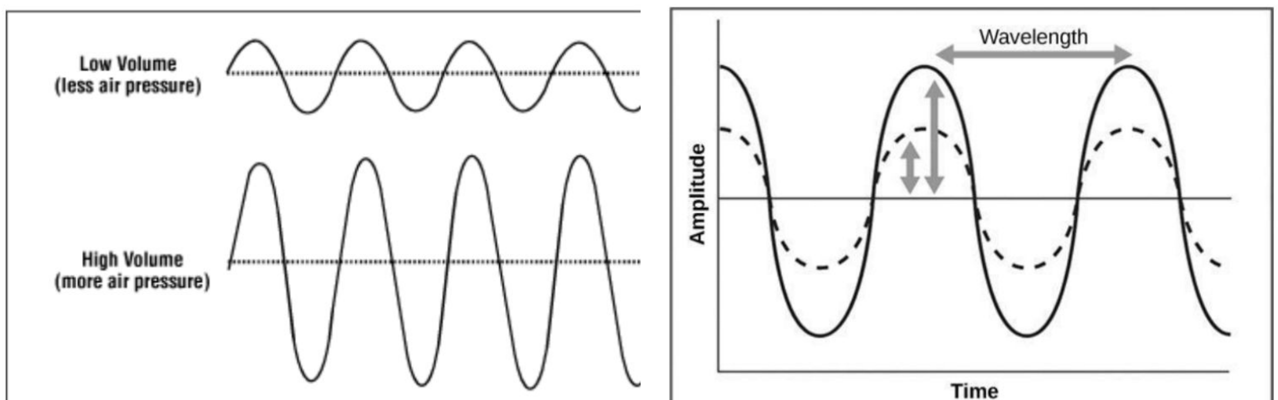


Teacher Background Content Knowledge

What is sound? Sound is closely related to motion because vibrating objects produce sounds we can hear -- The energy of the vibration can be seen (object moving back and forth), felt (feel vibrating object) and heard (through sound). When an object vibrates, such as vocal chords or a mallet hitting a drum, the vibrations push the surrounding air molecules in every direction. A medium is composed of molecules and can be solid, liquid, or gas. A medium is necessary for sound energy to be moved from one place to another because the sound travels by pushing molecules into each other in all directions emanating from the source, sort of like dominoes. There are many ways scientists represent sound energy in models. The examples on this page feature waves shown in two ways: using dots for particles and using wavy lines. Both show amplitude/volume. Both show frequency/pitch.

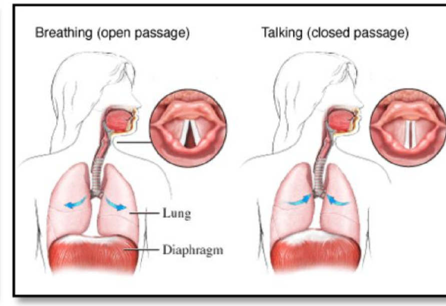
Sound energy travels out in all directions through a medium from the sound source. In this example, sound travels through the air in all directions and also through the table the alarm clock is vibrating as it rings. The dots represent air particles that get bumped in waves each time the hammer in the alarm bell hits the bell.



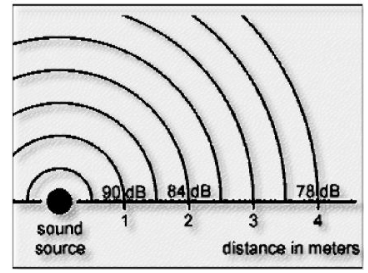


LEFT: These sounds have the same pitch (wavelength measured from crest to crest is equal) but different volume (amplitude, or height of wavelength). Volume is related to force. The top sound has less pressure when traveling through air than the sound on the bottom. RIGHT: Diagram labeling the amplitude (height of the wave) which is related to volume and the wavelength (from crest to crest) which is related to pitch.

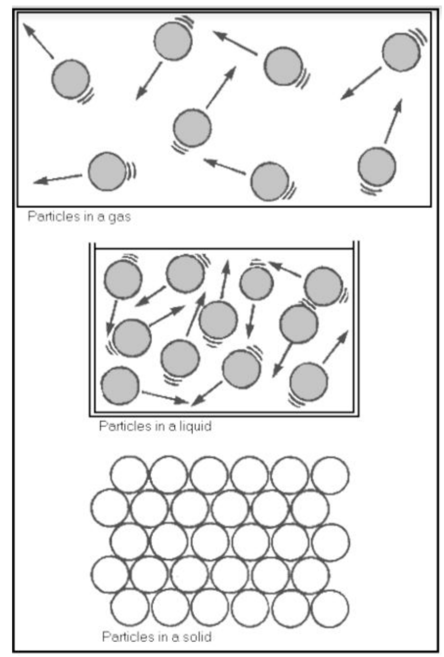
Properties of sound. Sound has specific properties, like pitch and volume. Higher pitch sounds have higher frequency. This means that the vibration goes back-and-forth faster and therefore is pushing surrounding molecules in pulses at a high rate over time. If the sound also has high volume, then the vibration pushes the molecules harder. For low pitch, the sound wave has a lower frequency. This means that the vibration is moving molecules at a slower rate (more time between pushes). Again, more volume is a push with more energy and the amplitude of the wave (vibration) will be larger but the rate of vibration will stay the same if it is the same pitch.



Body systems. The singer takes a deep breath and while exhaling uses muscles to make his vocal cords vibrate the air. The vibrating vocal cords jiggle air molecules that are inside his windpipe. The push is not constant, but pulsing (compression wave). These vibrations travel through air. Air molecules do not move across the distance but rather they push against neighboring air molecules, like dominoes. This domino effect eventually pushes air molecules against our ears drums. We hear these vibrations as sound. Our eardrums vibrate at the same rate as the original vibration so we can hear him (and may even feel the vibration, if loud enough).



Force-volume-distance relationship. The singer must be loud and close to the glass. Sound energy dissipates over a distance. A loud volume will jiggle the air molecules with more force (or air pressure) than a soft volume. If that force is really close to the glass, then the glass "feels" the pressure directly as opposed to if the singer stood 4 meters away from the glass and sang – dispersing the pressure over a distance as sound energy travels out in all directions. Then as the singer increases his volume, the wine glass really vibrates. The glass is flexing and wobbling. Air molecules are always bumping against the inside and outside of the glass. However adding sound energy to the system makes the molecules bump harder and more frequently than normal.

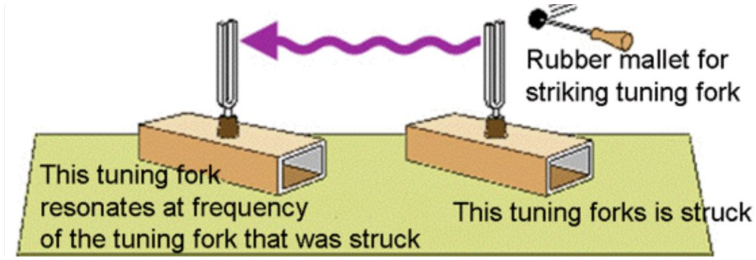


Energy-and-matter. The speed of sound depends on the medium through which it moves. Sound travels fastest through solids, slower through liquids, and slowest through gases. This can be explained by thinking about the arrangement and speed of particles in each phase of matter. It also depends on temperature. Yelling across a field on a cold day won't be heard as easily as yelling across a field on a hot day. Sound travels a bit faster in warm water than it does in cold water. At first glance, this seems illogical because the molecules are actually closer together in cold water than they are in warm, making it seem like it would be easier for sound to travel between them. But the critical factor in the speed of sound in water is actually the temperature—the higher temperature of the molecules creates a medium that allows sound to travel faster. For the singer-shatter-the-glass story, it is important to think about the molecules in the air (gas) and the molecules in the gass (solid) and how energy moves/transfers through them to cause movement and changes to the glass.

One question that helps think about the difference between sound (energy) transferring through air and air itself (matter) moving: *Why can we hear a fart before we smell it?* (Or *Why can we hear the spritz sound of a perfume bottle before we smell it?*) Keeping that domino analogy in mind, energy transfers out in all directions faster than any individual molecules. Another question to consider: *What is the difference between sound and wind?* Wind is the steady flow of air. Sound is the vibration of air molecules. Blowing at the glass won't break it (lots of moving air particles) but transferring energy by vibrating air particles, bumping into each other, will break the glass if it's the right pitch, yet the air molecules themselves (matter) don't move from point A to point B.

Material design. The glass flexes because air molecules bump into the outside of it with more force (extra force comes from sound wave). The glass will stay together through a little bit of wobbling, but over time the flexing back and forth will break the glass. The shape of the glass is important. In the video, students notice that the glass always breaks in the top part ("where the water goes") and never the stem ("the skinny bottom part you hold"). The wine glass top is thin and spherical shape. A thicker glass absorbs the sound vibrations and would not wobble or flex as much so it wouldn't break. There are many examples on YouTube of people singing to attempt to break thicker glassware without much success.

Resonance. At first the singer flicks the glass to hear the pitch the glass makes. The singer listens to hear if the glass is making noise, too (resonating).This is the pitch he must match in order to get the glass to vibrate. (If you listen closely at the beginning of the video, when the singer pauses to take a breath you can hear the glass 'humming' but it hasn't yet shattered. So he's at the right pitch but either not loud enough or not close enough.) When the singer hits the particular note, the wine glass begins to vibrate, too. You can find this resonant frequency by tapping the glass or running a wet finger around the edge. The closer the singer is to this pitch, the more the glass vibrates. The diagram shows how the vibration of one tuning fork can make another identical tuning fork begin to vibrate (just like the singer can make the glass vibrate if he hits the right pitch.) This is kind of like if the singer were one tuning fork, and the glass were the other, the singer can make the glass vibrate by making the "right pitch" (resonant frequency).



Two identical tuning forks can exemplify the idea of resonant frequencies affecting objects over a distance. Each tuning fork is identical. When one is struck, vibrations of the tuning fork vibrates the air and wood. Energy from that vibration bumps the surrounding air molecules in all directions. Those that bump into the other identical tuning fork make that identical fork start vibrating and making sound. To see this as a demonstration watch "Grandpa John Resonance" on YouTube https://www.youtube.com/watch?v=hiHOqMOJTH4

Student Models of Sound Energy

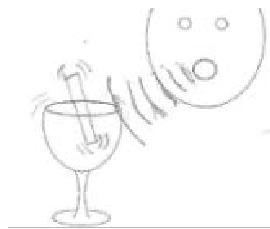
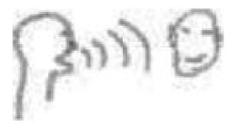
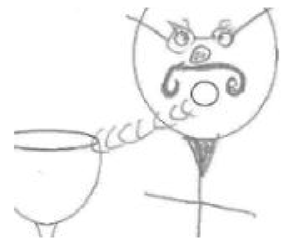
The information presented here is a blend of prior experiences teaching using this sound phenomenon with research about how students conceptualize sound energy (Eshach & Schwartz, 2006; Wittman, Steinberg, & Redish, 2003). There are many ways that students can represent and model sound and attributes of sound such as volume, pitch, where sound comes from, and where sound goes.

Sound Crescents

Sound crescents are semi-circular shapes that repeat to show sound spreading over a distance. They typically show sound going in just one particular direction (as opposed to sound circles/spheres that emanate in all directions from the sound source), but can be drawn emanating in all directions. Sound crescents do not show exactly how the sound energy is transferred (particles) but it does show spreading out.

How could 'sound crescents' be used as a representation help students understand sound?

- Represent volume by making crescents thicker/thinner
- Represent pitch by spacing crescents equally apart, closer spacing indicates higher pitch (and more pulses) and farther spacing indicates lower pitch (and fewer pulses/waves)

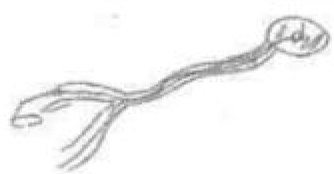





Sound Threads

Sound threads are typically used to show how sound travels in a particular direction and the number of threads may represent the intensity or volume of the sound. The top drawings show student initial models about how the singer's voice traveled to the glass. The student's drawing (middle) of "sound threads" in the stethoscope, traveling from the patient's heart to the doctor's ears is interesting because the student used the sound crescent idea to describe the sound in the air, but he uses the "thread" concept inside the stethoscope.

How could 'sound threads' be used as a representation help students understand sound?

- Represent volume (and the related idea of force) by using multiple threads for louder sounds and fewer numbers of threads for quieter sounds (and less force)
- Representing pitch is possible (change thread thickness so that a high pitch could be thinner and a low pitch could be thicker); however, this representation does not show frequency of the wavelength (or frequency of bumps) which is a key idea to understanding pitch. 'Sound threads' may not be the best representation if students are trying to model changing pitch.

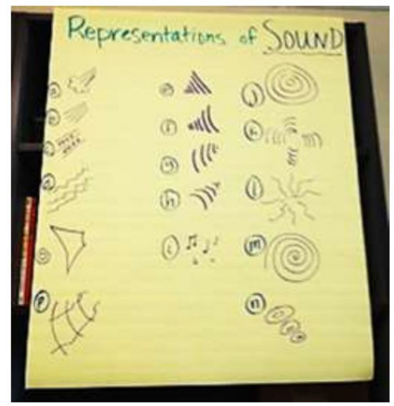

Even More Representations

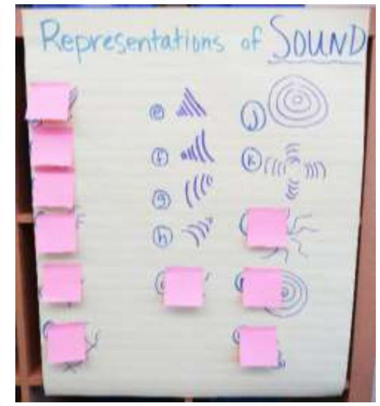
When given the opportunity, students can come up with a wide variety of ways to show sound. Students can explain why they chose to draw sound like that or explain what they are showing about sound in their model (i.e. the wiggle line gets bigger when the sound is louder; I showed sound like this because it's like the symbol on the computer for volume). Below is a photo of a chart from an upper elementary classroom showing all the different ways that class chose to show sound on their initial models (left). As the unit progressed, students decided which symbols were more useful and more often used and covered up ones they stopped using (right). This list will look different in a different class, but the purpose of this is to offer opportunities to show how students can model the same phenomenon in different ways and that decisions about which symbol to use can impact what is easy to communicate to a reader.

- How could ________ be used as a representation help students understand sound?
- How can a symbol be manipulated to show: volume? pitch? all directions? moving through matter? traveling over a distance?

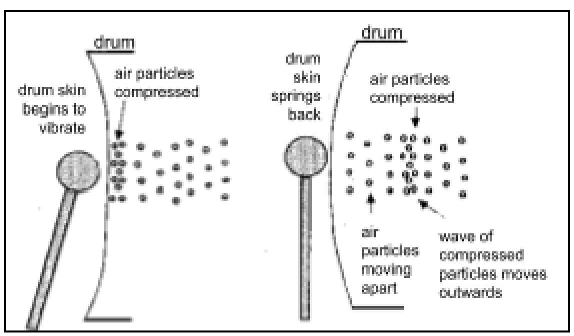
Productive discussions about model conventions

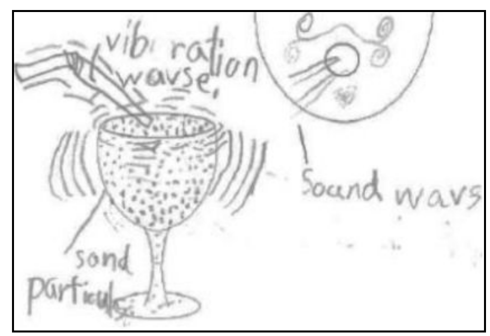
There is no 'best representation' that captures and models every property of sound. Each representation can be shaped through interactions with teachers and other students to foreground particular properties of sound energy such as volume, direction, dissipation over distance, pitch, frequency, etc. Some are better at representing some properties of sound than others which provides grounds for fruitful conversations. Students have to think about which ideas are most important to represent about sound energy in different contexts. Students may switch representations (without even knowing they do it) which can also be a place for productive discussion (i.e. *You used crescents to show sounds with the tuning fork, but with the singer, you drew 4 wavy lines to show sound. Tell me more about why you made that choice*.)





An additional modelling option may be introduced to help students think about how sound travels through different states of matter by attending to particle motion. The diagram below (left) maps the sound wave representation on to a particle wave representation to show compressions. Students may attend to particles on their own using their prior knowledge that matter is made of particles (below, middle and right). What will be new is helping students represent how sound energy can transfer through matter and into different materials and comparing and selecting representation of sound for specific purposes.





Reflections & Notes

Unit Overview

- **Pacing**: This unit takes 8 weeks if you have science time 4-5 times per week and around 10 weeks if you have science time 3 times per week and include optional lessons and the Engineering Design Project. Most lessons span 2-3 days where 1 day = approx. 50 mins.
- **Unit organization**: The order of lessons as written is intended to help students build on concepts over time. To support your students' learning, feel free to swap the order and make changes to the lessons suggested below (For example, L8 could fit well after L5)
- **NGSS**: The table below shows NGSS 3-dimensions combination foregrounded in the lesson but learning opportunities can include others.

Science Lesson Sequence

Lsn	Days	Science Lesson Sequence
L1	2	Introduce phenomenon, Elicit Students' Ideas & Experiences
L2	3	Human Systems: Sending and Receiving Sounds
L3	3	Decibels at a Distance
L4	2	Seeing Sound Waves: Amplitude and Wavelength
L5	2	Knock, Knock: Sound moves through matter (molecules)
L6	1	Update models: Add, change, questions
L7	2	Stop that Sound!
L8	*1*	*Optional: Finding the right pitch (resonance)*
L9	*1*	*Optional: How is sound different than wind? (more on molecules)*
L10	2-3	Update models and develop final explanations using evidence

Engineering Design: Noisy Places

Lsn	Days	Engineering Design: Noisy Places
A	3	Brainstorm & data collection
B	4	Design a solution, build and test prototype
C	4+	Proposing solutions to your school community

The engineering project is embedded at intentional places. Use your professional discretion about the pacing and sequence of what makes the most sense for your students' sensemaking. The current placement falls just after the science lesson that gives students some useful conceptual information to inform their design process.

Eliciting students' ideas, experiences, language & questions about the anchoring phenomenon

For more on eliciting, visit: Tools for Ambitious Science Teaching

Lsn	Purpose	Questions/Prompts in this Lesson	Key Terms	Next Generation Science Standards	Materials
1	Introduce phenomenon; Elicit Students' Ideas & Experiences 2 days *Why did the glass break? How did the singer break the glass?*	**Making observations about the phenomenon**: ● Before he sings: What is the singer doing? What is the glass doing? What do you see? What do you hear? ● While he's singing: What is the singer doing? What is the glass doing? What do you see? What do you hear? **Initial hypotheses**: ● Why did the singer flick the glass at the start? ● Why do you think he had a straw in the glass? Does he always have a straw? ● What do you think caused the glass to break? Why didn't the glass break right away? ● Do you think it would work if he were farther from the glass? ● Why do you think he has to be so loud? **Draw, write, then compare your ideas.** ● If you could see sound, what would it look like? How could you draw where the sound comes from and where it goes? ● What are all the ways we can represent sound? **Ask questions:** What questions/wonderings do you have now?	sound represent symbol	**SEP: Develop and use models** *Develop a model to describe phenomena* **SEP: Asking Questions** *Ask questions that can be investigated and/or researched* **PS1.A: Structure and Properties of Matter** *Matter of any type can be subdivided into particles too small to see* **PS3.A: Definitions of Energy** *Energy can be moved from place to place by moving objects or sound.* **PS3.B: Conservation of Energy and Energy Transfer** *Energy is present when there are moving objects, sound, light, heat. Energy can be moved place to place by motion and sound.* **Cause & Effect** *Cause & effect relationships are routinely identified and used to explain change* **CCC: Systems & System Models** *A system can be described in terms of its components and their interactions*	Teacher Guide (link) Chart paper & markers Sticky notes Video: - Singer break glass (link) - Slow-mo glass break (link) *Optional copies:* - *Model scaffold (link)* *Use one of these, give students options to choose, and/or develop your own scaffold.* *IMPORTANT NOTE: After students complete their initial models, keep them for students to revise them in lesson 6.*

Supporting Ongoing Changes in Student Thinking

For more on supporting ongoing sensemaking, visit: Tools for Ambitious Science Teaching

Lsn	Purpose	Questions/Prompts in this Lesson	Key Terms	Next Generation Science Standards	Materials
2	Human Systems 3 days *How did the singer make such a powerful sound?* *What parts in our body help us make sounds and hear sounds?*	**Reading Comprehension:** ● What was the reading about? ● What was one important piece of information it tells us about how our bodies send and/or receive sound? ● Did this information help answer and questions we had before (list from Lesson 1)? What questions do you have now? **Making observations: Hand on throat** ● What do you feel when you whisper? Hum? Talk? Yell? ● How is what you feel different between when you whisper and when you talk? Or yell? ● What do you observe about vibrations in your vocal cords as you increase your volume from hum all the way to yell? **Model-to-Explain:**Choose one of the sound representations from our chart from lesson 1. How can you show the difference between a hum and a yell using one of these symbols?	system force vibration	**SEP: Develop and use models** *Develop a model to describe phenomena* **SEP: Plan and carry out investigations** *Make observations to produce data to serve as basis for explanation* **LS1.D: Information Processing** *Sense receptors are specialized for particular information, then processed by the brain.* **CCC: Systems & System Models** *A system can be described in terms of its components and their interactions*	Teacher Guide (link) Reading: Human Voices (link) Reading: How We Hear (link) Ear drum demo: see lists *Optional*: Data sheet (link) or write in notebook *Optional Readings* - How We Hear (link) - Hearing Loss (link)
3	Decibels at a Distance 3 days *What happens to the volume of a sound as we increase our distance from it?*	**Reading Comprehension:** ● What is this reading about? ● What is a decibel? What do decibels tell us about sound? **Explore the tool: Using the decibel meter** ● What does the MAX/MIN buttons do? ● How loud a sound can you make? (Reading decimals) ● What happens when people talk when taking a measurement? **Collecting & Analyzing Data:** ● What was your highest measurement? Where was it? ● What was your lowest measurement? Where was it? ● Share data with the class and look for trends. Map it on a bird's eye view and shade in by decibel levels. ● What should we do if decibel readings seem "wrong"? Why do you think that number does not fit or is "wrong"?	decibel volume distance	**SEP: Use mathematics and computational thinking** *Measure and graph quantities to address scientific and engineering questions and problems.* **SEP: Analyzing & Interpret Data** *Analyze and interpret data to make sense of phenomena using logical reasoning* **PS3.A: Definitions of Energy** *Energy can be moved from place to place by moving objects or sound* **CCC Patterns** *Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena.*	Teacher Guide (link) Per student: - Rdg: Measuring Sound (link) - ¼ sheet data table (link) - 1 pair earplugs For the class (prep ahead): - 24 cones (6 colors, 4 each) - Trundle wheel - 1 air horn - Birds-eye map w/cone locations (sample) For each group: - Clipboard and pencil - Data strip by color (link) - 1 decibel meter (link)
A	Noisy Places: Brainstorm & Data Collection 3 days *What are some noise problems in our community?*	**Brainstorm ideas**: Compare individual lists of noisy areas in or around the school. Which ones are problems? **Decide on data collection plan**: Discuss and decide on a data collection plan with their teams. **Data collection**: Students make a data collection plan and get teacher feedback. Each team enacts their data collection plan today and/or over the next week , if needed. *(i.e. Take decibel meter, timer, and paper to lunch each day for 5 days and collect lunch noise data every 5 minutes over 25 min lunch.)*	data	**SEP: Ask Q's & Define Problems** *Define simple problem solved by tool, process, system; addresses criteria & constraints* **SEP: Plan & carry out investigations** *Make observations to produce data to serve as basis for evidence* **PS3.A: Definitions of Energy** **LS1.D: Information Processing** **Influence of STEM on Society & Natural World** *Engineers improve existing technologies or develop new to increase benefits, decrease risks, and meet demands.*	Teacher Guide (link) News video (link) Per student: - CNN article (link) - P&CH study (link) - Sci NB or project pages (link) For each group: - 1 decibel meter w/battery - Chromebook or computer - Other materials, as needed

Supporting Ongoing Changes in Student Thinking

For more on supporting ongoing sensemaking, visit: Tools for Ambitious Science Teaching

Lsn	Purpose	Questions/Prompts in this Lesson	Key Terms	Next Generation Science Standards	Materials
4	Seeing Sound Waves 2 days *How does the amount of force change a sound wave?*	**Reading comprehension:** ● What are two important pieces of information you found in the text about sound waves or sound energy? ● According to the reading, what does the word amplitude mean? **Analyzing observation data:** ● What did you feel/hear/see with a hard hit? Soft hit? ● How does changing the force to hit the tuning fork affect the strength of vibrations in the water and the volume of the sound? ● What was different between the little tuning fork and bigger tuning fork when hit with the same force? **Explain** *(connecting reading with observations)* ● Why did hitting the same tuning fork harder make more waves/splashes than the same tuning for hit softer? ● Why did the bigger tuning forks make different splash/water wave pattern than the smaller turning forks?	amplitude pitch wave energy	**SEP: Plan & carry out investigations** *Make observations to produce data to serve as basis for evidence* **SEP: Analyzing & Interpreting Data** *Analyze and interpret data to make sense of phenomena using logical reasoning* **PS3.A: Definitions of Energy** *Energy can be moved from place to place by moving objects or sound* **PS4.A: Wave Properties** *Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks)* **Cause & Effect** *Cause & effect relationships are routinely identified and used to explain change*	Teacher Guide (link) Readings: - Amplitude (link) - Pitch (link) Per group: - 1 dish tub ½ filled with water - 3 tuning forks - Paper towels
5	Knock, Knock: Energy can move through matter 2 days *How does sound energy travel?*	**Reading comprehension**: What are two important pieces of information you found in the text? What do you think this reading has to do with understanding sound energy? *(This question can guide the observation task.)* **Observations**: ● Put your ear on the table. Knock. What do you hear? Now, Lift your ear off the table. Knock again with the same force. Does it sound the same? ● *Optional Extension: Add distance. Find a longer table, like a cafeteria table. Can you still hear the knocking all the way down the table? Try ear-to-the-table and ear-in-the-air. Students may bring up experiences like listening to the ground or to railroad tracks to hear something coming rather than in the air.* **Model-to-explain**: Use the information about molecules from the reading to develop a model explaining why knocking sounds louder when your ears on the table even though you knock the same way.	force energy molecule	**SEP: Develop and use models** *Develop a model to describe phenomena* **PS1.A: Structure and Properties of Matter** *Matter of any type can be subdivided into particles too small to see* **PS3.A: Definitions of Energy** *Energy can be moved from place to place by moving objects or sound* **PS4.A: Wave Properties** *Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks)* **CCC Patterns** *Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena.* **Energy and Matter: Flows, Cycles, and Conservation** *Energy can be transferred in various ways & between objects*	Teacher Guide (link) Per student: - Reading: Stuff in Our World What is matter? (link) - Student sheet (link)

Updating models with evidence

For more on updating models, visit: Tools for Ambitious Science Teaching

Lsn	Purpose	Questions/Prompts in this Lesson	Key Terms	Next Generation Science Standards	Materials
6	Update models 1 day	**Orienting to prior learning:** ● What was your favorite experience so far? Why? ● What are some important ideas we have learned about together about sound? Start an explanation "gotta have" checklist. **Revise/update models**: Use "gotta have" checklist and sticky notes to add new ideas (green), revise an original idea (yellow), remove (blue), or ask questions (purple) on their original models. (Alterative: Students create new model and compare to original)	revise evidence	**SEP: Develop and use models** **PS1.A: Structure & Prop. of Matter** **PS3.A: Definitions of Energy** **PS3.B: Conservation of Energy and Energy Transfer** **PS4.A: Wave Properties** **CCC: Cause & Effect** **CCC: Systems & System Models**	Teacher Guide (link) 4 colors of sticky notes Students' initial models from lesson 1 *(Alternative: blank paper or blank model templates)*

Supporting Ongoing Changes in Student Thinking

For more on supporting ongoing sensemaking, visit: Tools for Ambitious Science Teaching

Lsn	Purpose	Questions/Prompts in this Lesson	Key Terms	Next Generation Science Standards	Materials
7	Stop that Sound! 2 days *Why can we hear noises from the hallway when we are inside the classroom? How can we stop sound energy?*	**Making observations**: Watch the snare drum video. What do you notice? What patterns do you observe between what is on the walls and the properties of the sound? Why do you think the sound changes? *Discuss echo or absorbing/insulating sound.* **Design-and-test:** Sketch designs with your team to decide how to block or stop as much buzzer sound as possible coming out of the pencil box. Once you can each explain your design choices, you can get materials to build and test. **Model-to-explain:** Develop a model that includes particles/molecules to explain why your design blocked or stopped some (or all) of the buzzer sound from leaving the box. How did the sound get out of the box?	molecule energy reflect (echo) absorb (insulate)	**SEP: Ask Q's & Define Problems** *Define simple problem solved by tool, process, system; addresses criteria & constraints* **SEP: Plan & carry out investigations** *Make observations to produce data to serve as basis for evidence* **PS3.A: Definitions of Energy** **LS1.D: Information Processing** **CCC: Systems & System Models** *A system can be described in terms of its components and their interactions* **Energy and Matter: Flows, Cycles, and Conservation** *Energy can be transferred in various ways & between objects*	Teacher Guide (link) Video: Snare drum with acoustic panels added (link) Class materials table: - Electrical tape - assorted materials Per student group: - empty pencil box - two 1.5 volt AA batteries - AA battery holder - 1 piezo buzzer - 1 decibel meter
B	Noisy Places: Design & test solutions 3 days	● Observe attempted noisy problem solutions around the school. Where is there insulation? Carpeting? Baffles? ● Brainstorm solutions to the noisy problem while addressing the design criteria and constraints. ● Prototype a solution to test. ● Test the prototype and collect data. ● Evaluate the proposed solution(s). *How well did this solution address or solve the noisy problem? What's your evidence? What might you change or try next?*	criteria constraints	**SEP: Designing Solutions** *Generate and compare multiple solutions to a problem based on how well they meet criteria & constraints of the design problem* **ETS1.B: Developing Possible Solutions** Communicating with peers about proposed solution, shared ideas can lead to improved designs.Use tests to identify failure points or difficulties, which suggest elements of the design to improve. **Influence of Sci, Engineering, & Tech on Society & Natural World**	Teacher Guide (link) Video: Eng design process (link) For each group: - Clipboard and pencil - Science notebook and/or project pages, part 5 (link) - 1 decibel meter w/battery Variety of building materials including padding, foam, cardboard, wood, poster board, cotton balls, etc.

Lsn	Purpose	Questions/Prompts in this Lesson	Key Terms	Next Generation Science Standards	Materials
8	***Optional*** *Find the right pitch* *(Resonance)* *1 day*	**Making observations**: Watch the teacher hum at the salted saran-wrapped glass bowl. When does the salt move? Watch the video of tuning forks and/or make observations of resonance box set. What happens to the 2nd tuning fork? **Just-in-time instruction**: What is resonance? Or resonant frequency? What does it have to do with pitch? **Model-to-explain**: How can one object (or person) make another object vibrate without touching it?	resonance frequency pitch wave	**SEP: Plan & carry out investigations** *Make observations to produce data to serve as basis for evidence* **PS4.A: Wave Properties** *Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing bet. peaks)* **Cause & Effect** *Cause & effect relationships are routinely identified and used to explain change*	Teacher Guide (link) Video:Singer break glass (link) Video: Grandpa John (link) For class demonstrations: - Resonance boxes w/mallet - Glass bowls - 2 sizes - Saran wrap (cover bowl) - Salt shaker - Safety glasses
9	***Optional*** *How do air molecules move?* *1 day*	**Making observations**: Follow directions for teacher demonstration spraying fragranced room spray. Who heard the spritz first? Who smelled the fragrance first? Last? How come? **Just-in-time instruction**: Review what we know about molecules and how sound travels. **Model-to-explain**: Use bodies to represent molecules and act out how air molecules move in the room spray scenario showing the difference between fragrance moving and sound moving.	molecule matter energy	**SEP: Develop and use models** *Develop a model to describe phenomena* **PS1.A: Structure & Prop of Matter** *Matter of any type can be subdivided into particles too small to see* **PS3.A: Definitions of Energy** *Energy can be moved from place to place by moving objects or sound* **Energy and Matter:** *Energy can be transferred in various ways & between objects*	Teacher Guide (link) For class demonstration: - Aerosol bottle of air scented freshener
	Pressing for evidence-based explanations			**For more on pressing for evidence-based explanations, visit: Tools for Ambitious Science Teaching**	
10	Update models, Write explanations using evidence 2-3 days	**Revise/update explanation checklist:** What are some important ideas we have learned about together about sound? Add to or revise an explanation "gotta have" checklist started in L6 **Revise/update models**: Use "gotta have" checklist and sticky notes to add new ideas (green), revise an original idea (yellow), remove (blue), or ask questions (purple) on their original models. (Alterative: Students create new model and compare to original) **Writing a scientific explanation**: Support students in writing about their claims with evidence from activities.	revise evidence	**SEP: Constructing Explanations** *Use evidence (e.g., measurements, observations, patterns) to construct an explanation* **PS1.A: Structure & Prop of Matter** *Matter of any type can be subdivided into particles too small to see* **PS3.A: Definitions of Energy** *Energy can be moved from place to place by moving objects or sound* **Cause & Effect** *Cause & effect relationships are routinely identified and used to explain change*	➢ Teacher Guide (link) ➢ Large blank paper or model templates (link) ➢ Students' model revisions from L6 ➢ Explanation Checklist from L6 ➢ Summary charts ➢ Sentence starter strips (link) ➢ Evidence-based explanation checklist quarter sheet (link) ➢ *Optional: 4 colors sticky notes*
C	Propose solutions to a sound-related problem in your school community 4+ days	**Days 1-4**: - Re-design and justify changes to the solution from Part B. - Argue with evidence to explain how/why and to what degree the solution addressed the noise problem - Provide feedback on written explanation based on criteria and data available as well as use of evidence and data. - Incorporate feedback. Finalize justification of problem solution. ***Days 5+*** *Optional: Rehearse and present to school community and/or create video of presentation and share. If possible, enact the solution, and further iterate to refine the design.*	critique compare	**SEP: Engaging in Argument from Evidence** Support an argument with evidence, data, or a model **ETS1.B: Developing Possible Solutions** Communicating with peers about proposed solution, shared ideas can lead to improved designs.Use tests to identify failure points or difficulties, which suggest elements of the design to improve. **Influence of Sci, Engineering, & Tech on Society & Natural World**	➢ Teacher Guide (link)

Unit Materials List

This list assumes a class of 32 students, 8 groups of 4 students. Classes can share non-consumables by staggering lessons or teaching at different times of the day. This list does not include common school supplies like notebooks, paper, sticky notes, rulers, pencils, colored pencils, pencil boxes, tissues, paper towels, etc. Pricing estimates as of 05/16/19.

Consumables

Item	*Qty*	*Price*
Ear plugs, individually wrapped Amazon	1 pkg	$22
Air horn Amazon	1	$16
1.5V batteries (to use with piezo buzzers), Amazon	1 pkg	$11
Electrical tape (to make buzzer circuit) DollarTree	4 rolls	$4
Saran wrap, DollarTree or grocery	$1	$1
Salt, DollarTree or grocery	$1	$1
Aerosol can of air freshener, DollarTree	$1	$1

Consumables subtotal $55

Non-Consumables

Item	*Qty*	*Price*
Decibel Meters w/9V battery Amazon $19 each	8	$152
Tuning forks, set of 4, SchoolSpecialty $15/ea.	4	$60
Resonance Boxes w/mallet SchoolSpecialty	1 set	$35
Trundle distance measuring wheel Amazon	1	$32
Glass bowl, set of 3 sizes Amazon	1 set	$13
Piezo buzzer with wires Amazon 5 per pkg	2 pkgs	$18
Plastic dish tubs, white/light color, DollarTree	8	$8
Optional: Scalp massagers, 2 pk Amazon	4 pkgs	$24
24 cones (6 colors, 4 of each), borrow from PE	24	borrow

Non-Consumables subtotal $345

Tracking Depth of Student Understanding

Note: Assessing student understanding should happen within three-dimensional tasks. Examine evidence from within a practice (like modeling) to see how students express a content understanding (DCI) using a cross-cutting concept (CCC). Use the rubric below helps identify and track growth over the unit. Start with initial models to plot initial understanding. Then pick a few assignments throughout the unit to plot on the rubric to see how students' understanding of those ideas and practices are changing. (See also NGSS Evidence Statements)

Disciplinary Core Ideas	1 - Below	2 - Approaching	3 - Meets Standard	4 - Exceeds Standard
PS1.A: Structure and Properties of Matter Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected.	No description, explanation, or drawing using knowledge of the particulate/ molecular nature of matter.	Recognizes/states that matter is made of particles. Reproduces generic diagram showing particle arrangement in solids, liquids, and gases.	Represents/communicates that matter is made of particles too small to be seen. Shows substances are made of one or more types of particles (molecules) such as showing that air is made of particles.	Uses knowledge of the particulate nature of matter to explain *how/why* energy (adding/ removing) changes particle motion and arrangement which results in observable changes in the volume of a sound or the distance the detectable sound travels.
PS4.A: Wave Properties Waves transfer energy. Waves of the same type can differ in amplitude (height) and wavelength (space between wave peaks).	No description, mention, or use of ideas of waves or vibrations.	Sound can make matter vibrate, and vibrating matter can make sound.	Waves are regular patterns of motion, which can be made in water by disturbing the surface. Waves of the same type can differ in amplitude and wavelength. Waves transfer energy and make objects move.	A simple wave model has a repeating pattern with a specific wavelength, frequency, and amplitude, and mechanical waves need a medium through which they are transmitted. This model can explain many phenomena including sound and light. Waves can transmit energy
PS3.A: Definitions of Energy Energy manifests in multiple phenomena, such as sound. A sound wave is a moving pattern of particle vibrations that transmits energy through a medium. *PS3.B: Conservation of Energy* Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems	No reference to sound or sound energy.	Reference to sound or sound energy as a label or note but no elaboration on sound as a manifestation of energy or that energy can move.	Energy can be moved or transferred from place to place by moving objects or through sound, light, or electric currents. Energy is present whenever there are moving objects, sound, light, or heat.	Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems and students track these transfers (i.e. When we can no longer hear a sound, so where did the energy go?)
LS1.A Structure & Function Plants and animals have structures that serve various functions in growth, survival, behavior, and reproduction. *LS1.D Information Processing* Animals have sensory receptors that detect information, and they use internal mechanisms for processing and storing it.	No reference to or use of knowledge about body systems to receive or produce sound.	Different animals, including humans, use their body parts to hear and communicate.	Identifies that animals, including humans, have body parts that capture (ears) and convey (mouth, vocal cords) different kinds of information needed for survival. Animals respond to these inputs to help them survive.	*(Explanations that include connections between the structure and function of body parts and waves and/or how energy is transferred or conserved.)*

Science & Engineering Practices	1 - Below	2 - Approaching	3 - Meets Standard	4 - Exceeds Standard
Developing and Using Models Building and revising simple models and using models to represent events: ● Use models to describe phenomena. ● Develop a model using an analogy, example, or abstract representation to describe a scientific principle.	No representation of sound. Representation of observation only. Not participating during tasks for revising, comparing, or discussing representations of sound or energy.	Communicates *that* sound is present, absent, or changing or that particles are moving in a model of a specific phenomenon Recognizes *that* there are different ways to symbolically represent sound but has difficulty using or interpreting more than one symbol.	Manipulates a representation to communicate *how* attributes of matter and/or energy change over a process or over time Uses modeling to explain relationships and patterns such as *where* energy transfers or *that* particles can change their position, speed, and direction based on whether energy is added or removed.	Compares, critiques, and selects particular representations of sound energy and how energy changes and/or transfers through matter.
Constructing Explanations Using evidence to construct explanations, describe and predict phenomena. ● Construct an explanation of observed relationships ● Identify the evidence that supports particular points in an explanation	Does not recognize patterns in data so cannot use those relationships in an explanation. Makes factual claims based on observations, patterns in data, and/or secondary sources but does not attempt to supply evidence. *(i.e. The sound was loud)*	Recognizes a pattern in the data but does not attempt to use that pattern to predict, describe, or explain phenomena. Supports claim with general connections to evidence source without specifics *(e.g. More force makes the sound louder.)*	Recognizes and uses a pattern in data to predict, describe, explain phenomena. Supports a claim in a larger explanation with appropriate and specific evidence such as numerical data points or quotes from text *(e.g. More force makes the sound louder because in our experiment I felt more force from my diaphragm and my yell was 43 decibels louder than my whisper.)*	Recognizes and uses data patterns to predict, describe, or explain phenomena, and relates it to science concepts. Supports a claim (or more than one claim) with specific and appropriate evidence AND critiques the reliability or validity of the source of the evidence.

* These 2 SEPs were selected to track growth over the unit. You may wish to assess and track different SEPs. Students should be engaged in all 8 SEPs at various points in the unit.

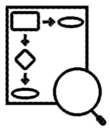
Student Name: ________________________________Period:_______ Table Group #:______

Jot a few short notes at different points in time in the unit to track evidence of student progress. Keep a class binder with one copy of this page per student. This is for teacher's quick reference to track student understanding over the unit. Ideal note-jotting times would be after L1, L6, and L10. Looking for classwide trends can help inform what changes teachers make to upcoming lessons to support ongoing changes to student thinking over time. Keep in binder alphabetically or sort student pages by table group.

	Date ____ / ____ / ____	Date ____ / ____ / ____	Date ____ / ____ / ____
DCI Structure of Matter			
DCI Energy: Definition & Conservation			
DCI Wave Properties			
SEP Developing and Using Models			
SEP Evidence-based Explanation			

Reflections & Notes

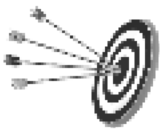
Lesson 1 Eliciting Ideas & Initial Models



Purpose

This lesson introduces students to the sound energy phenomenon that will anchor this unit. Students develop models using their initial understanding to explain how the singer shattered the glass. Students record and share ideas and questions about what allows the singer to make sound, properties of sound such as volume and pitch, proximity to a sound source, how sound travels, and how energy can cause changes.

Information gathered by eliciting students' initial observations and hypotheses about a phenomenon, and making a public record of these can inform instructional decisions for upcoming lessons. For more about eliciting students' ideas, see http://AmbitiousScienceTeaching.org

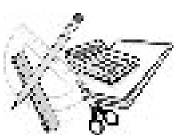


Learning Target

Focus questions
Why did the glass break?
How did the singer break the glass?

Learning Target
I can use observations to develop a model to explain how I think the singer was able to break the glass.
**You do not need to post a target statement. Instead, pose a question on the board.*

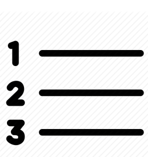
NGSS 3-D
SEP: Develop and use models *Develop a model to describe phenomena* **SEP: Asking Questions** *Ask questions that can be investigated and/or researched*
PS1.A: Structure and Properties of Matter *Matter of any type can be subdivided into particles too small to see* **PS3.A: Definitions of Energy** *Energy can be moved from place to place by moving objects or sound.* **PS3.B: Conservation of Energy and Energy Transfer** *Energy is present when there are moving objects, sound, light, heat. Energy can be moved place to place by motion and sound.* **CCC Cause & Effect** *Cause & effect relationships are routinely identified and used to explain change* **CCC: Systems & System Models** *A system can be described in terms of its components and their interactions*



Materials

Chart paper & markers
Sticky notes
Model scaffold (link) -- *Choose which version or offer both for student choice or create your own.*
Video: Singer break glass (link)
Video: Slow-mo glass break (link)

☑ **Teacher Preparation**:
Teachers, be sure to read the background knowledge and complete a model for yourself. Compare with a colleague.
- *How are you showing sound?*
- *What ideas do you anticipate?*
- *What challenges do you anticipate in getting ideas students down on paper?*



Lesson Step Summary

Part 1: 45 minutes
1. **Frame:** Introduce phenomenon of a singer breaking a glass: *Why did the glass break? How did the singer break the glass?* Elicit observations.
2. **Mini-Lesson:** Modeling-- How can we represent something we can't see?
3. **Model-to-Explain**: Students use the list of observations and video to develop a model explaining how and why the glass broke.
4. **Summarize:** As a class, create a list of initial hypotheses of what factors are important to the glass-breaking story.

Part 2: 45 minutes
1. **Frame**: Orient students back to the phenomenon and replay video.
2. **Mini-Lesson**: Comparing representations -- How did we choose to represent something we can't see? Silent gallery walk and discussion.
3. **Model-to-Explain**: Add to models and explanations.
4. **Summarize**: Create a list of questions from students. Then identify which questions are testable, researchable, or both.

Part 1

Purpose

1. Introduce phenomenon. Elicit students' observations.

a) Open with a statement of purpose for this unit and today's purpose of exploring the phenomenon of why a singer shattering the glass.

Watch video

b) Tell students to watch [this video of Jamie Vendera breaking a glass](). Ask students to watch silently and be ready to share with a partner:

- *Does the singer do the same thing with his body each time?*
- *Does the glass break each time?*
- *What do you notice about the sound he makes?*

Turn-and-Talk

c) Have students turn-and-talk about what they notice and observe.

Observations

d) Have students share observations. Create a list of observations from the video. Students will use this list later in this lesson and can add to this list if they make additional observations.

Public Record

This might sound like:

We are starting a science unit studying sound. Sounds are all around us as noise or music. We learn the rules about where we can make loud sounds and where we need to be quiet.

To anchor our learning together, I want to share this video I saw on Mythbusters of this singer who breaks glass with his voice. When I saw it, I wondered, 'How can he do that?' Let's make observations and get some ideas going about what causes the glass to break. As you watch, see if: Does the singer do the same thing with his body each time? Does the glass break each time? What do you notice about the sound he makes? *At the end of the video, turn and share with your partner about what you observed about the singer and the glass.*

Observations	Initial Ideas and Hypotheses
• Singer flicks glass and glass makes a sound. • Singer sings the same note the whole time. • Singer is really loud. • Glass breaks outward or explodes. • Singer takes a deep breath before singing.	

Management

<u>Management Tips</u>

These tips help orient students to each other rather than talking to/through the teacher. Try one or more:

- ❑ **Turn-allocation**: Students call on each other rather than the teacher.
- ❑ **Students do the writing**: Choose a student to write the list. Tell the writer they can ask clarifying questions to students and can ask for help from the class in summarizing longer observations. Be sure to remind the class to help the writer by sharing just *what* happened (observations) for right now.
- ❑ **Disagreements**: If students disagree about an observation, don't discuss it until the student replays the part of the video for everyone to observe more closely. Disagreements about observations are often settled by re-watching closely.

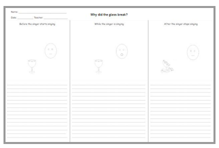
Turn-and-Talk

e) Elicit students' hypotheses about how/why the singer was able to break the glass. Have students choose one observation from the list. Think about how or what caused that observable action to happen and why it is important to the breaking-the-glass story. Give at least 15 seconds of silent think time. Turn-and-talk.

Mini-Lesson

2. Mini-Lesson: How can we represent something we can't see?

Tell/remind students that models are tools scientists use to communicate their ideas about how and why a phenomenon happens. Sometimes scientists have to represent things they can't see with their eyes. The challenge for this modeling task is: *How can we model something we can't see like sound?* Tell students there is not one "right" way to represent sound, rather whatever representation students choose should help them communicate about the sound like where it comes from, where it goes, how loud it is, quality/tone, etc. Tell students you are curious to see which ways they come up with to show sound. Remind students that models are paired with explanations so they need to use the lines below each part of the story to explain their ideas.



Develop Models

Back-Pocket Questions

3. Explore: Develop an initial explanatory model

Show students the model scaffold page. Tell students to sketch pictures, use symbols, sentences, and questions. Remind students that they can use the back if they prefer to work from a blank page; Include both pictures and words on their model to communicate their thinking about why the glass broke. As students develop their initial models, circulate to note what ideas you see from student work, to redirect students when needed, and to press students to add more with back-pocket questions.

Back-pocket questions:

- *Which observation do you want to start with?*
- *You observed ___. Why do you think that happened?*
- *How could you show ___ on your model?*
- *We can't see sound, so how are you going to choose to show it?*
- *What's going on that we can't directly observe that you think could be causing _____?*

Share & Connect Circle

4. Summarize: Develop a list of hypotheses and important factors

Have students sit in a large circle with their models flat on the floor in front of them. One student shares one idea. Students listen. If students agree and want to share more, show thumbs up. The first students calls on the next student. That student shares then after exchange, looks for thumbs, calls on next student, and so forth. The share-and-connect keeps going without much teacher intervention. The purpose is to understand the initial ideas as a class.

List Hypotheses

(Note: Intervene if any arguments begin as we need to hold off on scientific argumentation until later on since we have not collected any common evidence yet.)

At the end of 5 or so minutes of share-and-connect, the teacher can make some summarizing moves to get ideas jotted on the hypothesis list. It may not include all ideas in the room but some main ones that we agree are important or places students disagree.

Observations	Initial Ideas and Hypotheses
• Singer flicks glass and glass makes a sound. • Singer sings the same note the whole time. • Singer is really loud. • Glass breaks outward or explodes. • Singer takes a deep breath before singing.	• The sound made the glass break. • The sound has to be loud and close to the glass. • The vibrations make the glass shatter. • The singer has to have enough air to make it happen.

Example Share-and-Connect Circle Dialog: Eliciting Ideas

This level of back-and-forth in the example below takes practice. At first, start with each student sharing and calling on the next student. Then over time, layer in the next move of asking a question, responding, using student names, clarifying the use of pronouns (you said 'it' what do you mean?), etc.

Josiah: I think the singer had to be loud to give enough pressure to break the glass….*(looking for thumbs, calls on Martin)...* Martin?

Martin: I agree with you, Josiah, the singer had to be loud. Can you say more about pressure?

Josiah: The sound is loud, like if you stand in front of a speaker that's loud you can feel the sound, not just hear it. So I think the pressure is the feeling of the sound. So if it's a loud sound it has more pressure and too much pressure breaks the glass.

Martin: Thank you. I didn't say the word pressure but I agree with you... *(looking for thumbs)...* Carolina?

Carolina: I agree the singer had to be loud and I showed it with really dark sound lines. I also think the loudness took time to for the glass to break…. *(looking for thumbs)...* Eli?

Eli: I agree that it has to be loud, but I didn't think about time. Can you say more about time, Carolina?

Carolina: Yes. Like in the video the singer had to sing for a while before glass broke. It didn't happen right away. Like the glass couldn't take the pressure anymore.

Eli: Oh yeah. I agree. He sang for like 5 seconds before the glass broke. I wonder if he sang even louder...Could he be louder? Well, if he could, would it happen faster? … Um… *(looking for thumbs)...* Belinda?

Belinda: I want to add to something Josiah said about the singer putting pressure in the sound. Like, I think part of pressure is also being close to the glass… uh… *(looking for thumbs)...* Josiah?

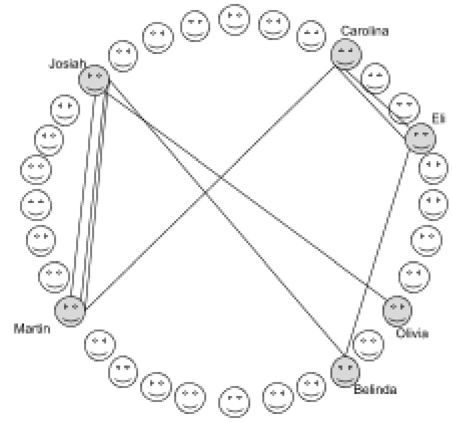
Josiah: Yes. Um. So… like pressure has… Pressure has 2 parts to it.... maybe more. Like pressure needs the loudness of the sound and needs to be up close. Like if I stood across the room from the loud speaker, I wouldn't feel as much pressure as right up close… *(looking for thumbs)...* Olivia?

Olivia: This might not be related but I'm wondering about the straw. Sometimes he has a straw and sometimes he doesn't. Does anyone have ideas about why he has a straw?... *(looking for thumbs, no thumbs, pauses then looks at teacher)...* Can we turn-and-talk about the straw? *(Teacher nods yes).* Okay, turn and talk about the straw.

[Discussion continues after turn-and-talk for 2 more minutes.]

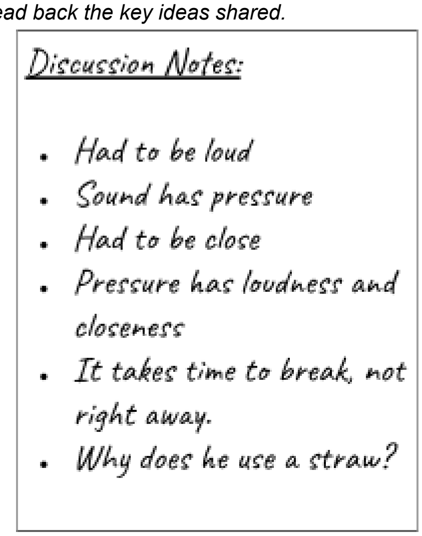
As students are talking, a teacher or student can keep a running record of notes to track ideas shared. Also, another student could keep a discussion circle tracker drawing lines between students to make sure to invite other students into the conversation, particularly if they have thumbs up but haven't been called yet.

Discussion Map

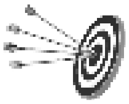


Discussion Notes

Notes jotted by the teacher (or student) while listening to the discussion to use at the end to read back the key ideas shared.

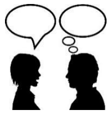


Part 2



Purpose

Watch videos



Turn-and-Talk

1. Frame: Recap phenomenon using videos

a) Orient students back to the phenomenon by showing the observation and hypothesis list from Part 1 and replaying [this video of Jamie Vendera breaking a glass](#).

b) Introduce a new video clip, a [slow motion clip of an amplifying speaker breaking a glass](#) *(Note: This video is muted but tell students the sound is similar to the single, consistent loud sound the singer produced.)*

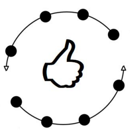
c) Have students turn-and-talk about what they notice and observe. Then ask: *Is there anything we should add to our list of observations or hypotheses?*

Mini-Lesson

2. Mini-Lesson: Comparing representations -- How did we show sound?

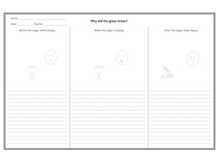
a) Have a few students quickly show how they represented sound. Create a chart of the different ways students came up with. Discuss: *How are they similar? How are they different?*

Teacher Preparation
[Watch this short clip ahead of time](#). It is from an upper elementary classroom. Prepare yourself for what you might hear during this lesson where students share a bit about their model and the teacher collects sound representations on a chart and compares them.



Gallery Walk

b) Close the mini-lesson with a quick silent gallery walk. Have students place their models-in-progress on their desks. Students take a silent 2 minute gallery walk, looking and reading over models. Remind students to look for different ways we are showing sound and also to see what ideas are in the room. Maybe students will see something that sparks an idea or something to add on their model.



Develop Models

3. Explore: Look for sound representations then add to Models

Give about 10 minutes to work on and add to models of how and why the singer was able to shatter the glass. If students claim they have included all the ideas possible, have them start to generate questions on sticky notes. *Note: Collect and keep students' initial models for analysis and for end-of-unit comparison as one way to detect evidence of student growth and sensemaking.*

Asking Questions

4. Summarize: What do we want to figure out about sound?

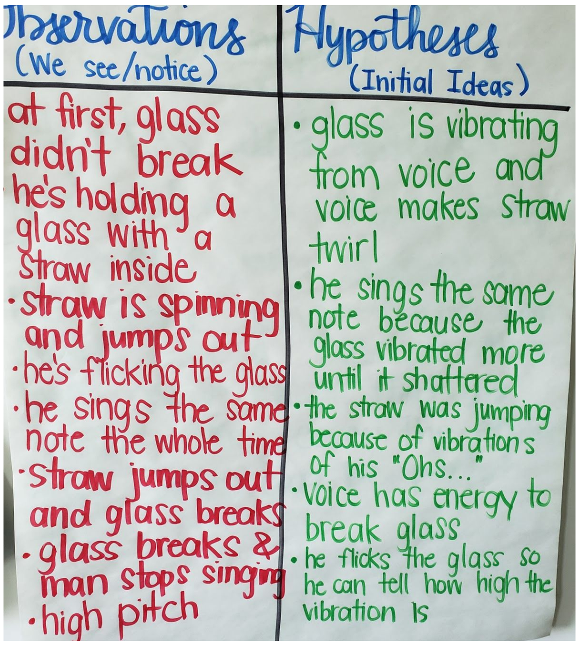
Have students jot questions on sticky notes. Stick them on the board and arrange into categories by similar theme. Then use the 3 questions (at right) and jot responses on a chart. Students will likely suggest or ask about experiences that are in this unit.

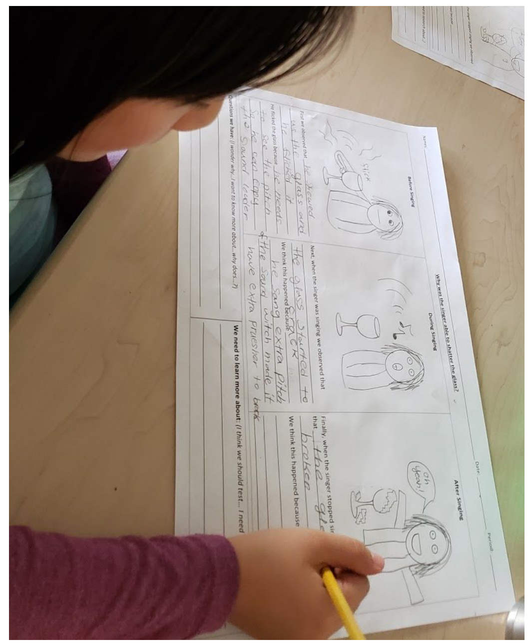
- What are some things we aren't sure about?
- What kinds of experiences do we need to learn more?
- What are some ways we could test our hypotheses?

Analyze Student Work

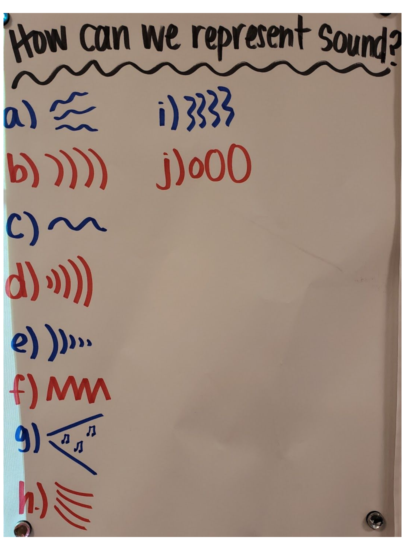
Collect student models and examine ideas. Jot notes about ideas, questions, and connections students shared. This informs next steps and connections you can make in future lessons. Here is one rubric and tracker (p 13-14 of overview document) you could use to keep track of student thinking at key points in this unit. *What trends do you see in student work? Do you think students would have shown more if there was something changed about the model scaffold, prompts, and/or teacher support?*

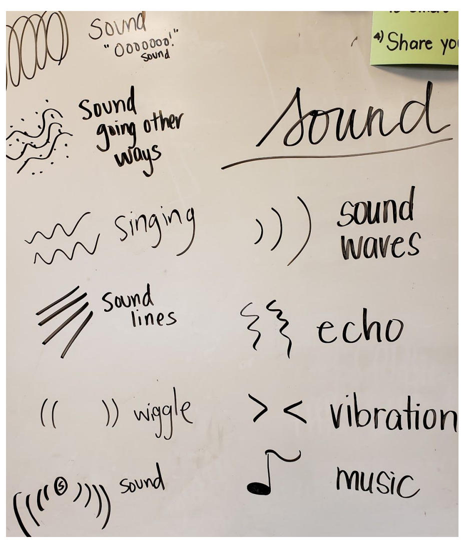
Photos from Lesson 1

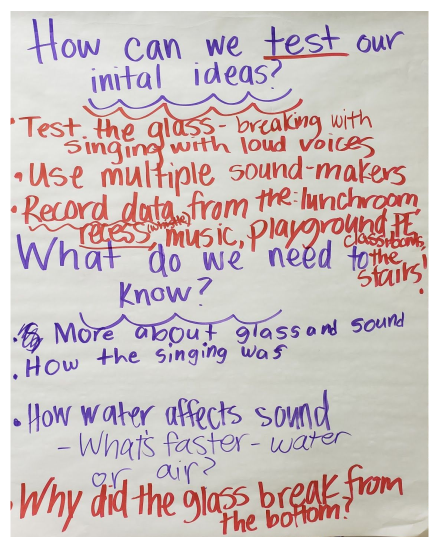




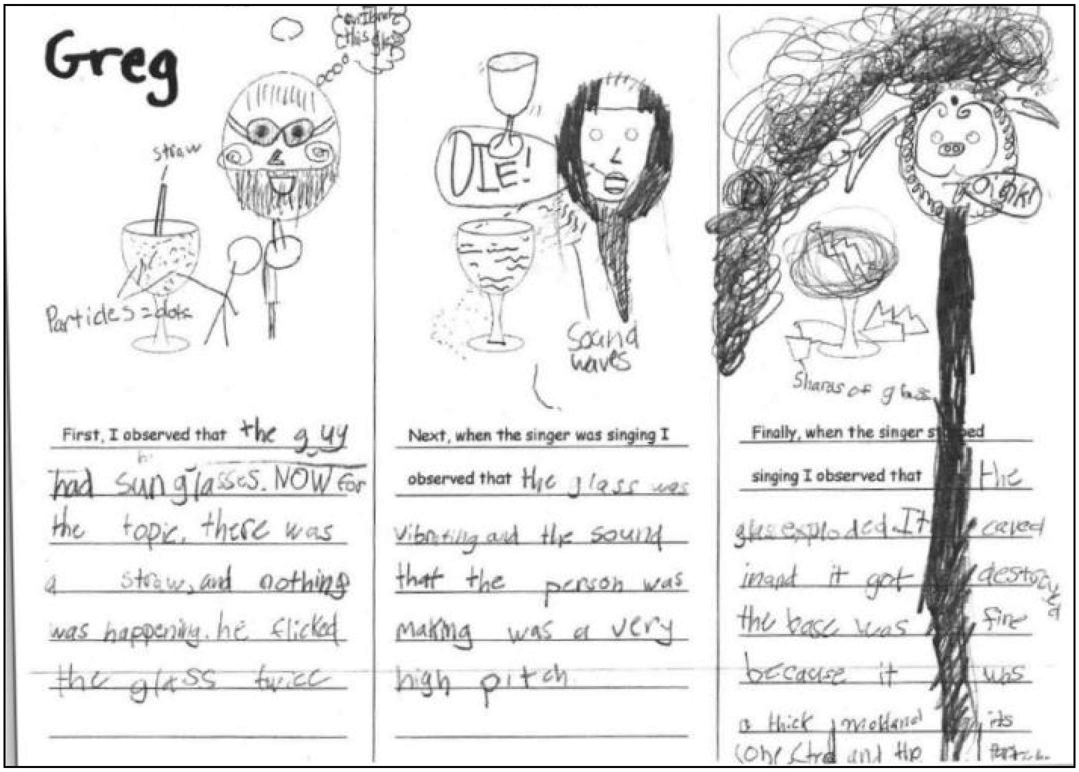
This class made a list of observations after watching the video. Students worked on their models before coming together and creating a list of hypotheses. This public list can be a resource for students to use on their models. For example, if students noticed the straw jumped out of the glass, what do they think happened to make it move? How can they show that in your picture and words? Or if they think the "voice has energy to break glass" how can students represent energy? Where does it come from? Where does it go? What does the energy do?



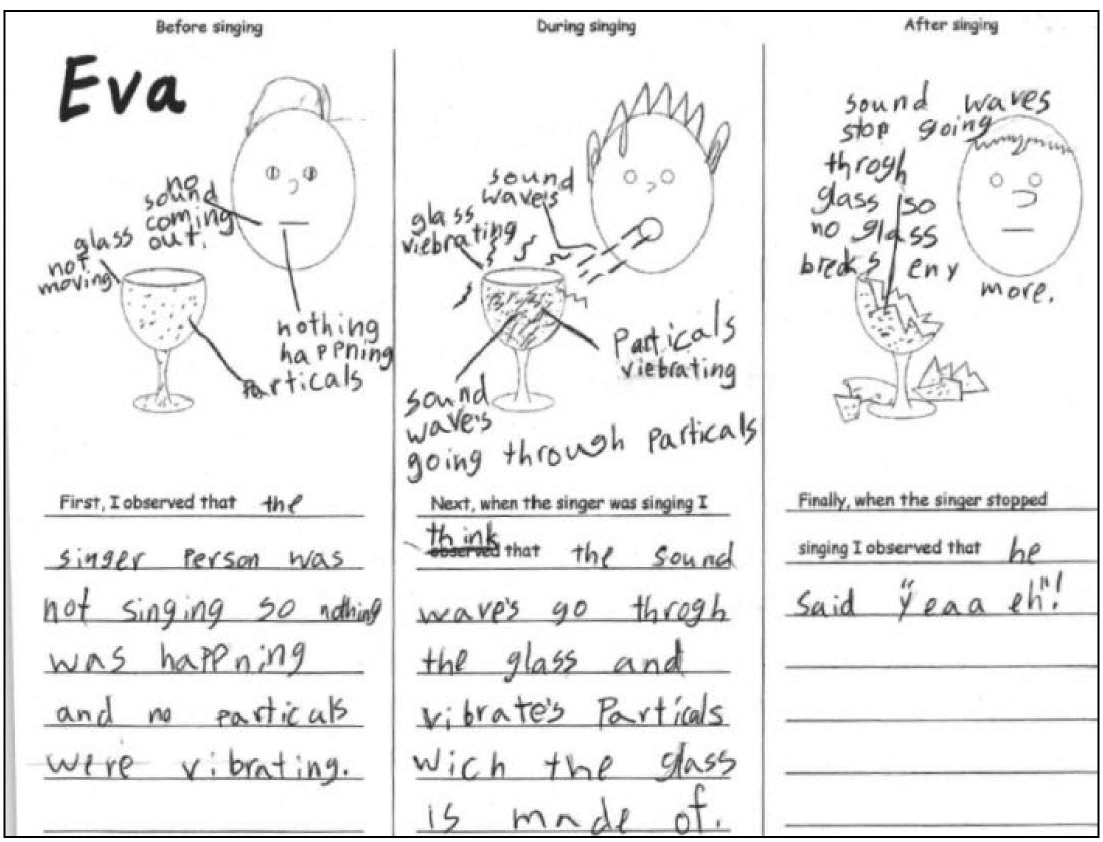




Left and center: These photos are from two different classrooms as a way to publicly represent the different ways students in the classroom decided to represent sound in their models. Keep this chart as a reference throughout the unit. Right: Students considered how to test some of their initial questions and ideas and identified what else they wanted or needed to know.



"First I observed that the guy had sunglasses. Now for the topic. There was a straw and nothing was happening. he flicked the glass twice. Next when the singer was singing I observed that the glass was vibrating and the sound that the person was making a very high pitch. Finally when the singer stopped singing I observed that the glass exploded. It caved in and it got destroyed the base was find because it was thick moldened(?) its one straw and particles."



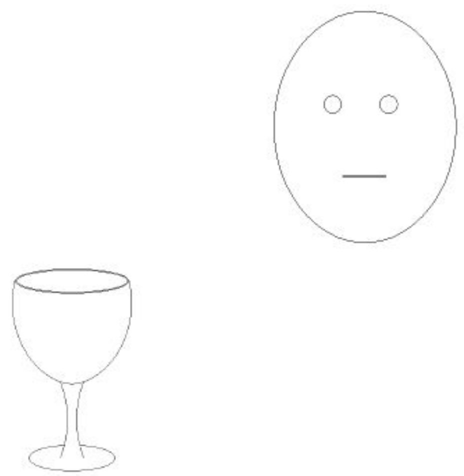
"First, I observed that the singer person was not singing so nothing was happening and no particles were vibrating. Next, when the singer was singing I think the sound waves go through the glass and vibrates particles which the glass is made of. Finally when the singer stopped singing I observed that he said "yeaaaeh"!"

Name: ______________________________

Date: __________ Teacher: _______________

Why did the glass break?

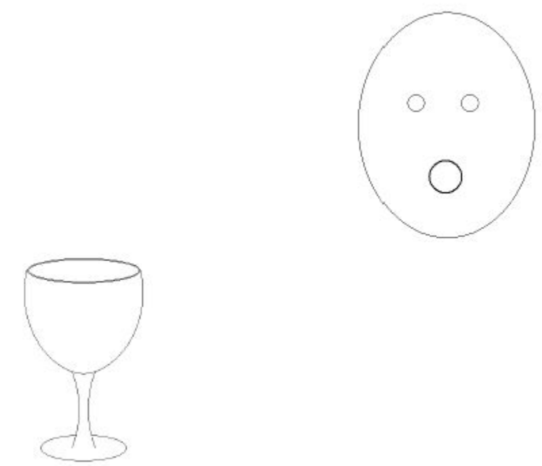
Before the singer starts singing



Did you….?

- ❑ Draw sound using a symbol or representation
- ❑ Show how or where sound travels
- ❑ Explain or show more than one observation

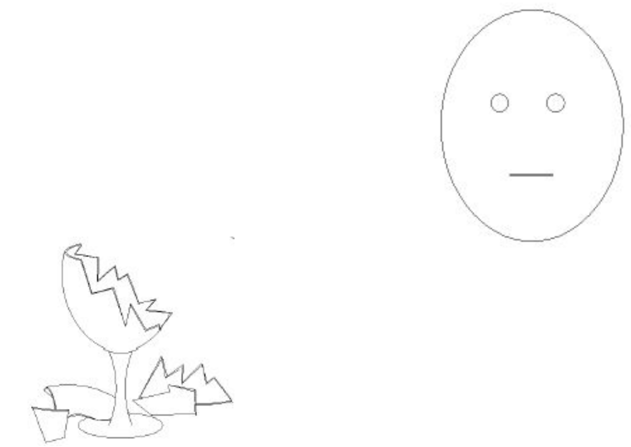
While the singer is singing



Did you….?

- ❑ Draw sound using a symbol or representation
- ❑ Show how or where sound travels
- ❑ Explain or show more than one observation

After the singer stops singing



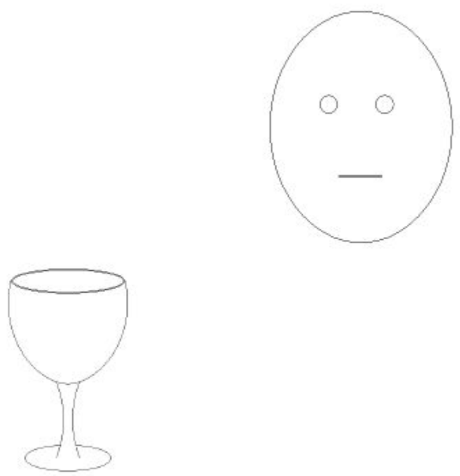
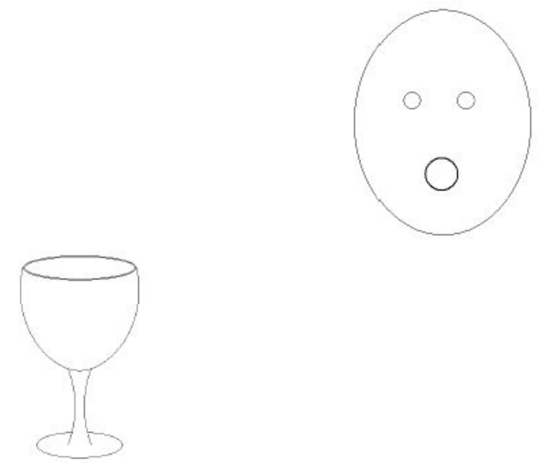
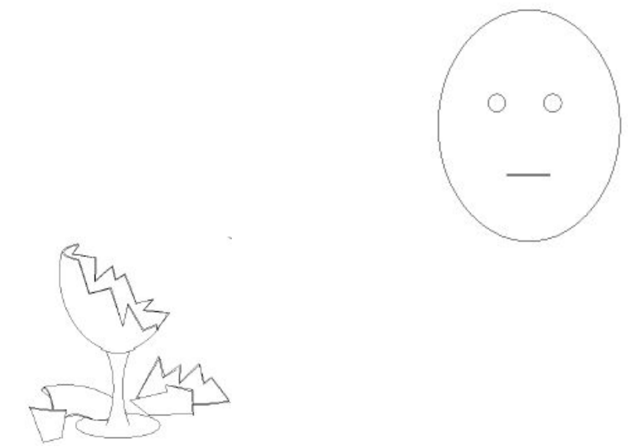
Did you….?

- ❑ Draw sound using a symbol or representation
- ❑ Show how or where sound travels
- ❑ Explain or show more than one observation

Name: ______________________________

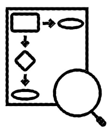
Date: __________ Teacher: _______________

Why did the glass break?

Before the singer starts singing	While the singer is singing	After the singer stops singing
		

Reflections & Notes

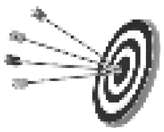
Lesson 2 Human Systems: Sending and Receiving Sounds



Purpose

The singer vibrates air and that vibration travels through the air to the glass making it vibrate, too. But how does the singer vibrate air? What parts of the body system work together to produce sounds and to receive and interpret sounds? In this lesson, students observe the force and vibration in their own bodies to make sounds of different volumes and use information from non-fiction text to explain how and why this works.

This lesson provides some new information to students through non-fiction text, paired with a physical experience to help students make sense of how the singer could make such a loud sound. For more about supporting ongoing changes in student thinking, see http://AmbitiousScienceTeaching.org



Learning Target

Focus questions

How did the singer make such a powerful sound? What parts in our body help us make sounds and hear sounds?

Learning Target

I can use observations and information from non-fiction text to explain how humans make and understand sounds.

**You do not need to post a target statement. Instead, pose a question on the board.*

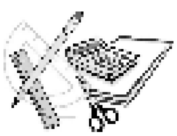
NGSS 3-D

SEP: Develop and use models *Develop a model to describe phenomena*

SEP: Plan and carry out investigations *Make observations to produce data to serve as basis for explanation*

LS1.D: Information Processing *Sense receptors are specialized for particular information, then processed by the brain.*

CCC: Systems & System Models *A system can be described in terms of its components and their interactions*

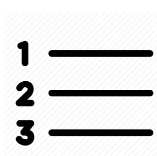


Materials

Chart paper, markers, sticky notes
Video: Singer break glass (link)
Reading: Human Voices (link)
Reading: How We Hear (link)
Ear drum demo: see lists
Optional: Data sheet (link)
Additional Optional Readings:
- KidsHealth: What are ears? (link)
- Hearing Loss (link)

☑ **Teacher Consideration**:

Students get new information through readings in this lesson. Decide how best to structure the reading task to make new information accessible to all students. Every student should have a copy to put in their notebook (NB) for today and future reference.



Lesson Step Summary

Part 1: 45-50 minutes
1. **Frame:** Introduce lesson by connecting to a student question/idea from L1
2. **Mini-Lesson:** Gather new information. Read to find out about systems.
3. **Explore**: Make sounds at different volumes. Identify patterns/relationships
4. **Summarize:** As a class, start the summary table.

Part 2: 45-50 minutes
1. **Frame**: Review Part 1 focus Q. Pose today's Q on send/receive sound.
2. **Mini-Lesson**: Gather new information. Read to find out about systems.
3. **Explore**: Compare and critique eardrum models.
4. **Summarize**: Add to summary table.

Part 3: 40-45 minutes
1. **Frame**: Introduce Q: How can we represent different volumes of sound?
2. **Mini-Lesson**: Refer to sound representation chart from L1. Ask students to draw symbols in different ways to convey a whisper versus a yell.
3. **Model-to-Explain**: Students sketch models of whisper, hum, talk, yell.
4. **Summarize**: Quick comparison of 3 student models under the document camera. Then add "connections" column on the summary chart.

Part 1: Parts of system that help us make sounds

1. Framing: Orienting students to today's concept(s).

Purpose

a) Open with a statement setting today's purpose and connecting to student's contributions related to the singer's voice from lesson 1 *(how loud it was, how deeply he had to breathe in, etc).* Tell students that today they will learn how parts inside our bodies help us make sounds like when we whisper, hum, talk, yell, and sing.

Watch video

Read today's focus question: *How did the singer make such a powerful sound? What parts in our body help us make sounds and hear sounds?*

Observations

Turn-and-Talk

b) Replay [the singer video] just once and ask students to focus observations on the singer's body. Begin thinking about ideas to answer today's focal question. Have students turn and talk about: *What did you notice about the singer and his body?* Why do you think he did that? Think for 10 seconds. Now, turn-and-talk.

This might sound like:

Last class, we started thinking about how the singer was able to break that glass with his voice. We noticed the singer did a few things with his body that we think helped to break the glass. Today we will learn more about what parts work together inside our bodies to help us and the singer make powerful sounds.

Let's watch our singer one more time. Pay attention to what he does with his body. [Play video] *Think about: What did you notice about the singer's body? Why do you think he did that?* [10 second think time] *Turn and talk with a partner.* [Time for turn-and-talk.]

I could hear that many of you noticed how he took a deep breath before making the noise and that he was loud. Some people said forceful or powerful. Today we will learn more about how parts inside our bodies work together in a system to make that kind of sound. Before we collect some data on some noises ourselves, let's read a little bit about the parts are inside our bodies.that help us make sound with our voice. [Transition to reading task.]

2. Just-in-Time Instruction: Read & discuss parts of a system

Mini-Lesson

c) Introduce new content about the parts inside our bodies that help us make sounds with our voices by reading [a short informational text].

Read for information

New Terms

d) After reading, come together as a class quickly to review new terms and the purpose of each part *(diaphragm, lungs, windpipe, vocal cords, mouth)* Have students touch-and-say each part on their bodies as you review the names. Some students may feel their pulse on their throat rather than the vocal cords. Students should also tape or glue the half sheet reading in their science notebooks by the end of this lesson so they have it for reference.

☑ **Teacher consideration:**

Decide how to structure the reading task. A few possibilities:

- *Individual*: Students go read on their own. Write one sticky note to bring back to the whole class about information from the text that helps answer today's focus question.
- *Partner*: Students whisper read with a partner. Write one sticky note together to bring back to the whole class about today's focus question.
- *Preview & Review*: Preview text as a class. Look at diagrams. *Will information from this text help to answer our focus question?* Spend 2 minutes previewing, then students individual/partner read for 5 minutes before coming together to identify the names and functions the parts that work together to make sounds.

3. Explore: Make Observations & Identify Patterns

Back-Pocket Questions

Tell students they will make observations about how their lungs, diaphragm, vocal cords and mouth work together. They should pay attention to how it feels to make different sounds like whispering, humming, talking, and yelling. Students will use the same phrase to test each volume (For example, “Go Seahawks!”)

Observations

Students can use the optional data sheet or take notes directly in their notebooks about what they observe. They will make four different volumes using the same phrase. Put one hand on their diaphragm (just below lungs) and one hand/fingers over their vocal cords.

Back-pocket questions:

- What do you notice as your volume increases from whispering to talking to yelling?
- How is what you feel different between when you whisper and when you talk?
- What do you observe about how you breathe or how your diaphragm muscle feels when you increase or decrease your volume?

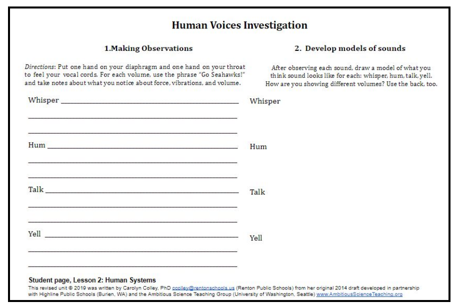
Analyze data

Students should notice some general patterns in their observations, such as:
To make a louder volume (yelling):

- Take a deeper breath
- Push harder with diaphragm
- Feels straining in neck/throat
- Vibrations in neck near vocal cords feel stronger

To make super quiet volume (whisper):

- Don't need a big breath
- Not much pushing from diaphragm
- No straining in neck
- Can't really feel any vibrations, maybe no vibrations from vocal cords



Human Voices Investigation

1.Making Observations

Directions: Put one hand on your diaphragm and one hand on your throat to feel your vocal cords. For each volume, use the phrase "Go Seahawks!" and take notes about what you notice about force, vibrations, and volume.

Whisper ______

Hum ______

Talk ______

Yell ______

2. Develop models of sounds

After observing each sound, draw a model of what you think sound looks like for each: whisper, hum, talk, yell. How are you showing different volumes? Use the back, too.

Whisper

Hum

Talk

Yell

Student page, Lesson 2: Human Systems
This revised unit © 2019 was written by Carolyn Colley, PhD ccolley@rentonschools.us (Renton Public Schools) from her original 2014 draft developed in partnership with Highline Public Schools (Burien, WA) and the Ambitious Science Teaching Group (University of Washington, Seattle) www.AmbitiousScienceTeaching.org

4. Summarize: QuickWrite. Start the summary table for this lesson.

Quick Write

Have students do a silent quick write in their notebooks about today's focus question using their observations from today's investigation using information from the reading. *How did the singer make such a powerful sound? What parts in our body help us make sounds and hear sounds?*

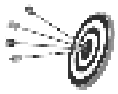
Summary Table

After quickwrite, come together to start adding to the public summary chart for this lesson. Use some think time and pair-shares to decide on: What information should we put on our summary chart to remember for later? What do we think is important about what we did? observed? and learned today? Are we able to answer our focus question for today? Do we have lingering questions? Jot notes on the chart and leave room to add after parts 2 and 3. Tell students they can go back and add a sentence or two to their quickwrite based on this discussion to remember important ideas for later.

Take 2 minutes for science notebook housekeeping (tape loose papers, fold pages over so they don't stick out, title, date, etc).

Part 2: Parts of our body that help us receive sound

1. Framing: Orienting students to today's concept(s).



Purpose

Open with a statement setting today's purpose and connecting to student's observations and ideas from part 1.Tell students that today they will learn how parts inside our bodies help us receive and hear sounds.

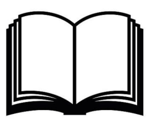
Read today's focus question: *How do we hear sound? What parts in our body help us receive sounds?*

This might sound like:

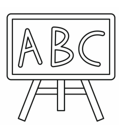
Last class, we started thinking about how the singer was able to break that glass with his voice and we read about what parts work together inside our bodies to help us and the singer make powerful sounds.

Today we will get more information about other parts inside our bodies.that help us receive, hear, and understand sounds.

2. Just-in-Time Instruction: Read & discuss parts of a system



Read for information



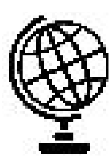
New Terms

Teacher consideration: Decide how to structure the reading task.

Introduce new content about what the parts inside our bodies that help us receive sounds with a short informational text.

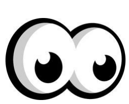
After reading, come together as a class quickly to review new names and the purpose of each part *(ear canal, ear drum, cochlea).* [If students have questions about these parts for people who cannot hear or have limited hearing. Students may find this reading helpful, too. Use it now or later depending on your time.] Students should tape or glue half sheet reading in their science notebook by the end of this lesson so they have it for reference.

3. Explore: Analyze physical models and identify aspects to improve



Physical model

Turn-and-Talk



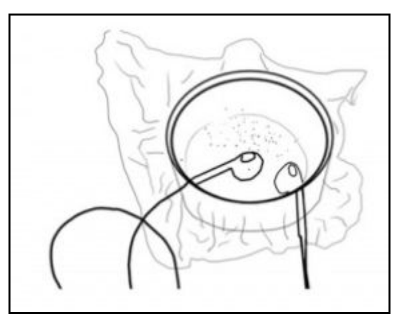
Observations

Show students the materials for building the eardrum models. Ask: *If you were going to build a model to show how the eardrum works, what parts would be important to include in your model? What would the parts need to show?* Turn-and-talk.

Show the directions for creating the eardrum models. You could choose to build one of each as a class demonstration or have multiple sets of materials for table groups to construct and test both models. As students construct and use the models ask: *What's similar between them? What's different? What does the material represent in real life?* (e.g. Saran wrap is like the eardrum because…)

Back-pocket questions:

- What does each part of the model mean or represent in real life?
- What do these models have in common?
- What are these models missing? What would you add?

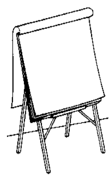


Science Friday Eardrum Model

Quick Write

4. Summarize: QuickWrite and add to the summary table for this lesson

Have students do a silent quick write in their notebooks about today's models and the focus question using their observations and using information from the reading. In particular, students can write about comparing their physical models to the real life system and how it works. Students may have noticed their banging or speakers had to be close to their eardrum model to be able to see the salt or rice jump/vibrate. Why might that be? (More on the importance of distance in lesson 3).



Summary Table

After quickwrite, come together to start adding to the public summary chart for this lesson. Use some think time and pair-shares to decide on: What information should we put on our summary chart to remember for later? What do we think is important about what we did? observed? and learned today? Are we able to answer our focus question for today? Do we have lingering questions? Jot notes on the chart and leave room to add after part 3. Tell students they can go back to add a sentence or two to their quickwrite based on this discussion to remember important ideas for later.

Management Tips

These tips help orient students to each other rather than talking through the teacher.

- ❏ **Turn-allocation**: Students call on each other rather than handing off through the teacher. Students can also call for a turn-and-talk or 10 second think time if they notice other students seem like they all want to share something or seem confused
- ❏ **Students do the writing**: Choose a student to write on the chart or on sticky notes to put on the chart. Tell the writer they can ask clarifying questions to students and can ask for help from the class in summarizing longer observations or ideas.
- ❏ **Disagreements**: If students disagree about an idea, or whether or not something should go on the chart, call for a think-pair-share to get some input from the class. Some options include: put a question mark next to an uncertain idea, but agreed on ideas in marker directly on the chart but uncertain/tentative ideas go on sticky notes, remind students that this chart does not need to capture every idea either and they can add their own ideas in their science notebooks.

If students have not done so already, take 2 minutes for science notebook housekeeping (tape in loose papers, fold pages that stick out, title, date, etc).

Optional Research Extension

Extend & Follow-up

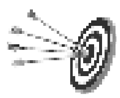
Students may have questions about how people who have limited or no hearing can communicate or other questions to research. Some of your students may also have hearing devices or wonder why many newer classrooms now have a microphone or speaker system. Provide some research time for students to learn about a question they are interested in. This could turn into creating a slide deck as a class where each student adds a slide with their question as a title, some information they found and an image or two.

Students may also be interested in making models of lungs and vocal cord systems. You can provide materials and students build their own without directions or use these as starting places: Vocal cords / Diaphragm w/lungs

Part 3: Representing sound

1. Framing: Orienting students to today's concept(s).


Turn-and-Talk


Purpose

Open with a statement setting today's purpose and connecting to student's observations and ideas from parts 1 and 2. Have students remind themselves of what they have done so far using the summary table. Tell students that today they will put ideas together about how we make and hear sound. Read today's focus question: *How can we model different volumes of sound?*

This might sound like:
Let's look at our summary chart to remember what we've done so far. Turn and talk with a partner about something you've done, read about, or learned about over the past few days. [Turn-and-talk time]. *Today we will come back to our representations of sounds chart we started last week and think about how to use these different ways of drawing sound.*

2. Just-in-Time Instruction: Developing Models


Mini-Lesson

Tell/remind students that models are tools scientists use to communicate their ideas about how and why a phenomenon happens. Sometimes scientists have to represent things they can't see with their eyes. Students have already been drawing sound from lesson 1 (See chart, 'Representation of sound'). Have students look at the chart from Lesson 1 that includes all the different ways students came up with to show sound. Remind students there is not one "right" way to represent sound, rather whatever representation students choose should help them communicate about the sound like where sound comes from, where it goes, how loud it is, etc.

Tell students that today their job is to develop a model from our whisper, hum, talk, yell investigation: *Where does the sound come from? Where does it go?*


Turn-and-Talk

Do a quick demonstration to recap the investigation. Have 2 students at the front of the room. One is the listener and the other makes the hum, whisper, talk, and yells the phrase, "Go Seahawks!" This context will help students get started as they can draw the two students and then create a model of the different sounds. Have students think-pair-share about: *Which representation from the chart will you choose to show the different sounds? Why that one?*

3. Explore: Developing Models


Develop a Model

Students sketch their models in their science notebooks. Students might choose different representations for different sounds or change something about the representation and use the same symbol but make it bigger or thicker to show louder volumes and thinner and smaller to show quieter sound. As you circulate, use the back-pocket questions to help students get started and add to their models.

<u>Back-pocket questions</u>:

- If we could see the sound what would it look like?
- Which representation of sound will you choose to show the sound?
- Where did the sound come from? Where did it go?
- What parts are involved in making and receiving sounds?
- How will you show the difference between a whisper and a yell?

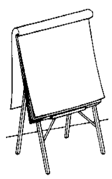
4. Summarize: Discuss Modeling Choices, Wrap-up Summary Table

Share & Discuss

Have students share their model with a partner. Remind students to listen and ask questions before telling about your model. Some questions might me:

- How did you show the difference between the loud yell and the quiet whisper?
- Did you show where the sound came from? What parts help create the sound?
- Did you show where the sound went? How do you know it went there?

Choose a few to show to the class. What are the different ways students chose to show volume of the sound?

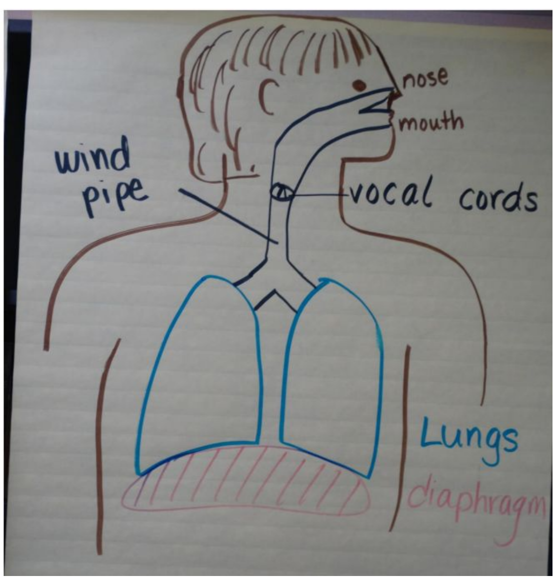


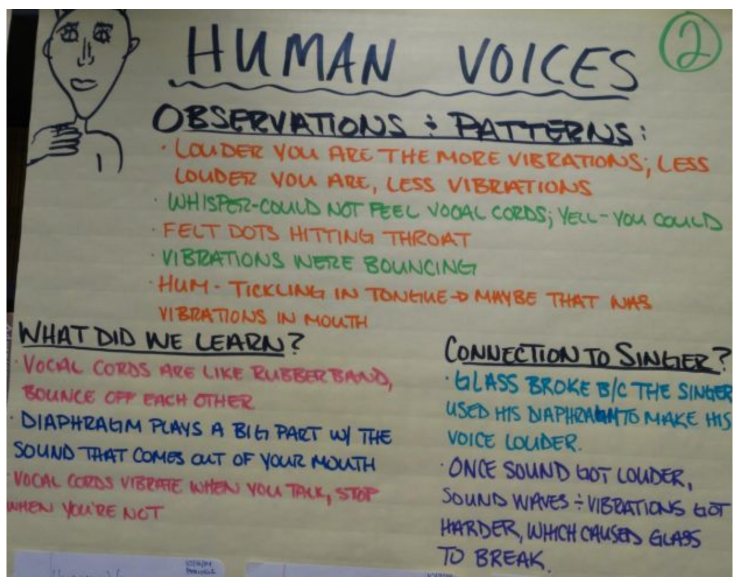
Summary Table

After share-and-compare, wrap up the summary table for this lesson. Use some think time and pair-shares to decide on: What information should we put on our summary chart to remember for later? What do we think is important about what we did? observed? and learned today? Are we able to answer our focus question? How does what we have learned about parts inside our bodies help us explain how the singer could shatter the glass? Do we have lingering questions? Jot notes on the chart.

If students have not done so already, take 2 minutes for science notebook housekeeping (tape in loose papers, fold pages that stick out, title, date, etc).

Photos from Lesson 2





Top, left: Diagram of labeled parts;
Top, right: Summary chart from lesson 2
Bottom, left: Teacher re-drew a student's representation larger and in black marker so it would be easier to see and asked other students during the summarize to turn-and-talk about what this scientist was wanting to communicate:

- How did she show different volumes?
- Which representation did she use?
- Does this clearly show a difference between whisper and yell?
- Why do you think whisper was just a flat line with no waves?

Human Voices Investigation

1.Making Observations

Directions: Put one hand on your diaphragm and one hand on your throat to feel your vocal cords. For each volume, use the phrase "Go Seahawks!" and take notes about what you notice about force, vibrations, and volume.

Whisper ____

Hum ____

Talk ____

Yell ____

2. Develop models of sounds

After observing each sound, draw a model of what you think sound looks like for each: whisper, hum, talk, yell. How are you showing different volumes? Use the back, too.

Whisper

Hum

Talk

Yell

Human Voices Investigation

1. Making Observations

Directions: Put one hand on your diaphragm and one hand on your throat to feel your vocal cords. For each volume, use the phrase "Go Seahawks!" and take notes about what you notice about force, vibrations, and volume.

Whisper ____

Hum ____

Talk ____

Yell ____

2. Develop models of sounds

After observing each sound, draw a model of what you think sound looks like for each: whisper, hum, talk, yell. How are you showing different volumes? Use the back, too.

Whisper

Hum

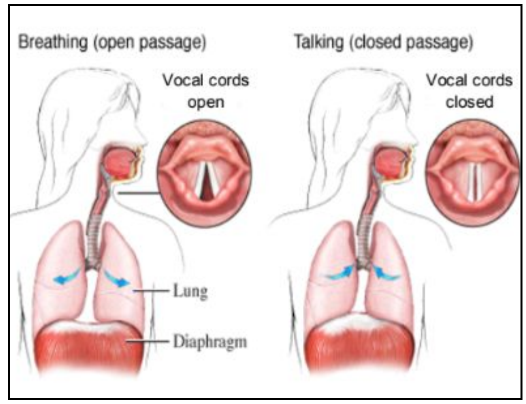
Talk

Yell

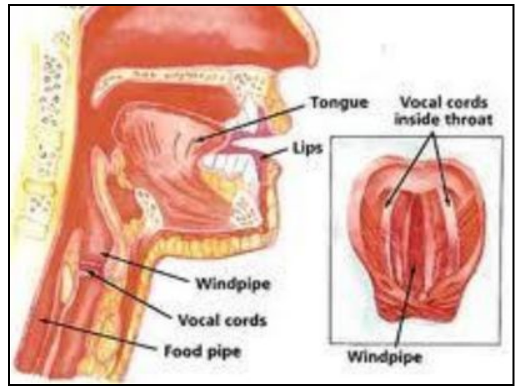
Student page, Lesson 2: Human Systems

This revised unit © 2019 was written by Carolyn Colley, PhD ccolley@rentonschools.us (Renton Public Schools) from her original 2014 draft developed in partnership with Highline Public Schools (Burien, WA) and the Ambitious Science Teaching Group (University of Washington, Seattle) www.AmbitiousScienceTeaching.org

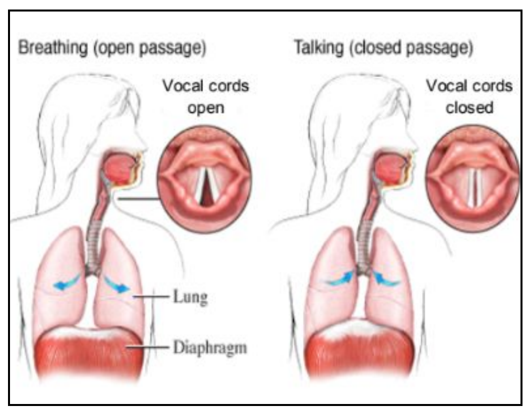
Human Voices



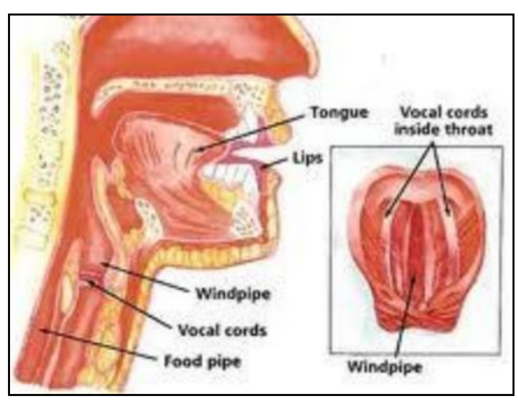
There are parts inside your body which work together to help you make sounds like talking, yelling, and singing. The main parts are the diaphragm muscle, lungs, windpipe, vocal cords, and mouth. The diaphragm is a muscle below your lungs. You can control your diaphragm muscle. To make loud sounds, you can feel your diaphragm pushing hard. The diaphragm muscle pushes on your lungs. Your lungs are kind of like balloons. Your diaphragm muscle helps move air in and out of your lungs. The windpipe connects to your mouth and nose to your lungs. When you breathe in, air goes in your mouth or nose, through the windpipe, and fills up your lungs. Your vocal cords are inside your windpipe. When you talk, you exhale. The muscles in your neck control your vocal chords. When you talk, your vocal cords get closer together than when you are just breathing. Lungs are also important. You breathe in just before you talk or sing. While you are talking or singing, you are slowly breathing out. As air leaves your lungs, it moves up, out, and passes through your vocal cords. As the moving air passes over your vocal cords and gets vibrated when you hum, talk, or yell. The sounds we make with our mouths travels out into the air for other people to hear and feel.



Human Voices



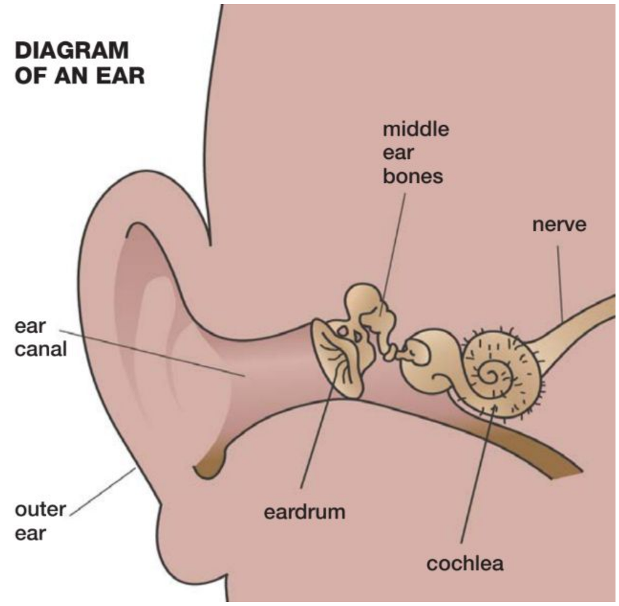
There are parts inside your body which work together to help you make sounds like talking, yelling, and singing. The main parts are the diaphragm muscle, lungs, windpipe, vocal cords, and mouth. The diaphragm is a muscle below your lungs. You can control your diaphragm muscle. To make loud sounds, you can feel your diaphragm pushing hard. The diaphragm muscle pushes on your lungs. Your lungs are kind of like balloons. Your diaphragm muscle helps move air in and out of your lungs. The windpipe connects to your mouth and nose to your lungs. When you breathe in, air goes in your mouth or nose, through the windpipe, and fills up your lungs. Your vocal cords are inside your windpipe. When you talk, you exhale. The muscles in your neck control your vocal chords. When you talk, your vocal cords get closer together than when you are just breathing. Lungs are also important. You breathe in just before you talk or sing. While you are talking or singing, you are slowly breathing out. As air leaves your lungs, it moves up, out, and passes through your vocal cords. As the moving air passes over your vocal cords and gets vibrated when you hum, talk, or yell. The sounds we make with our mouths travels out into the air for other people to hear and feel.



Student Reading, Lesson 2: Human Voices

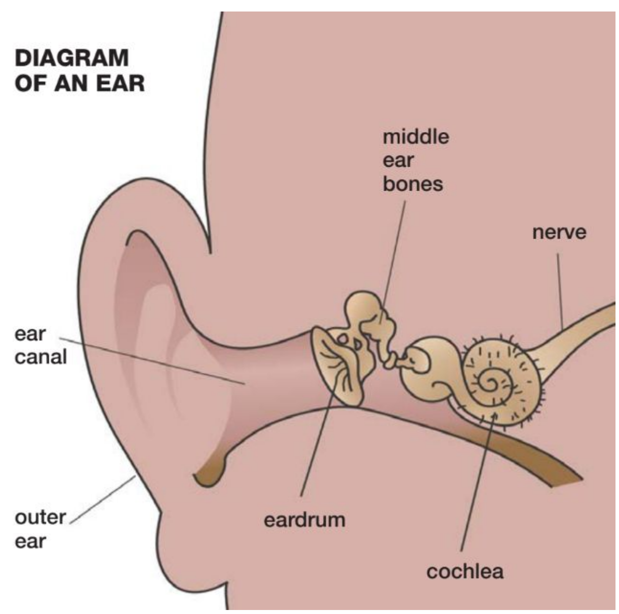
How We Hear

Your ears are shaped to gather sound waves and move the sound into your ears. The part of your ear on the outside of your head is called the outer ear. A tube inside the ear, called the ear canal, carries sound from the outer ear to the eardrum. The eardrum is a tightly stretched patch of thin skin. It is like a tiny drum. When sound waves from the outer ear hit the eardrum, it vibrates. The eardrum passes vibrations into the middle ear, which has three tiny bones. When the eardrum vibrates, the bones vibrate. These bones pass the sound vibrations to the deepest part of each ear—the inner ear. The most important part of the inner ear is the cochlea. The cochlea looks like a tiny snail shell. It is filled with liquid that vibrates when the bones of the middle ear vibrate. Tiny hairs lining the inside of the cochlea change the vibrations to signals. Each sound causes different vibrations that then make different signals. The hairs inside the cochlea connect to nerves. The thin, threadlike nerves carry messages from the ear to the brain. The brain interprets the signals. If the sound of an alarm clock buzzing reaches your ear, the vibrations in your ear send a signal to your brain. Your brain interprets the signal and tells you to get out of bed.



How We Hear

Your ears are shaped to gather sound waves and move the sound into your ears. The part of your ear on the outside of your head is called the outer ear. A tube inside the ear, called the ear canal, carries sound from the outer ear to the eardrum. The eardrum is a tightly stretched patch of thin skin. It is like a tiny drum. When sound waves from the outer ear hit the eardrum, it vibrates. The eardrum passes vibrations into the middle ear, which has three tiny bones. When the eardrum vibrates, the bones vibrate. These bones pass the sound vibrations to the deepest part of each ear—the inner ear. The most important part of the inner ear is the cochlea. The cochlea looks like a tiny snail shell. It is filled with liquid that vibrates when the bones of the middle ear vibrate. Tiny hairs lining the inside of the cochlea change the vibrations to signals. Each sound causes different vibrations that then make different signals. The hairs inside the cochlea connect to nerves. The thin, threadlike nerves carry messages from the ear to the brain. The brain interprets the signals. If the sound of an alarm clock buzzing reaches your ear, the vibrations in your ear send a signal to your brain. Your brain interprets the signal and tells you to get out of bed.



Hearing Loss

The many parts of the ear must work together for good hearing. If any part stops working properly, hearing will be affected. Hearing loss can happen because a person was born with parts of the ear that didn't form correctly or don't work well. Other hearing loss can happen later in life because of an injury or illness. Some people need a hearing aid to make sounds louder. Hearing aids are like tiny amplifiers. They make sounds louder and clearer. Hearing aids deliver amplified sounds from the eardrum and middle ear to the inner ear or cochlea. Hearing aid technology can adjust the volume of sounds automatically.

People use the words deaf, deafness, hearing impaired, or hard of hearing when they're talking about hearing loss. Someone who has hearing loss might be able to hear some sounds or nothing at all. Some people can't hear sounds even with a hearing aid. People who cannot hear learn to use their sight, touch, and other senses in place of hearing. Some use sign language to communicate. Others learn to read lips and feel vibrations.

The Most Frequent Causes of Hearing Loss:

Source: Mayo Clinic

American Sign Language: Example Words

Hearing Loss

The many parts of the ear must work together for good hearing. If any part stops working properly, hearing will be affected. Hearing loss can happen because a person was born with parts of the ear that didn't form correctly or don't work well. Other hearing loss can happen later in life because of an injury or illness. Some people need a hearing aid to make sounds louder. Hearing aids are like tiny amplifiers. They make sounds louder and clearer. Hearing aids deliver amplified sounds from the eardrum and middle ear to the inner ear or cochlea. Hearing aid technology can adjust the volume of sounds automatically.

People use the words deaf, deafness, hearing impaired, or hard of hearing when they're talking about hearing loss. Someone who has hearing loss might be able to hear some sounds or nothing at all. Some people can't hear sounds even with a hearing aid. People who cannot hear learn to use their sight, touch, and other senses in place of hearing. Some use sign language to communicate. Others learn to read lips and feel vibrations.

The Most Frequent Causes of Hearing Loss:

Source: Mayo Clinic

American Sign Language: Example Words

Student Reading, Lesson 2: Human Systems

Comparing Eardrum Models

Kids Health Eardrum Model

https://kidshealth.org/en/kids/experiment-eardrum.html

Materials

- Glass bowl
- Plastic wrap
- 20 grains of uncooked rice
- Cookie sheet

Directions

1. Stretch a piece of plastic wrap over your bowl. Make sure the wrap is on there tight. The plastic wrap represents the eardrum.
2. Place about 20 grains of uncooked rice on the top of the plastic wrap.
3. Now you need some noise. Hold the cookie sheet close to the plastic wrap. Hit the cookie sheet to create a "big bang" noise and watch the rice grains jump. Now you know how sound causes your eardrum to vibrate, sending messages to your brain about the sounds you're hearing!

Science Friday Eardrum Model

https://www.sciencefriday.com/educational-resources/make-a-model-eardrum-to-detect-sound-waves/

Materials

- Plastic soda bottle or rigid plastic cup
- Rubber band
- Balloon or plastic wrap
- Sugar, salt, sand, or other sand-like substance
- Scissors
- Smartphone, small speakers or earbud headphones

Directions

1. Carefully cut the bottle or cup to make 5 centimeter ring cylinder shape.
2. Stretch the balloon or plastic wrap over one end of the ring. Make sure it is pulled tightly. Secure with rubber band.
3. Sprinkle the salt, sand, or sand-like substance on top of the plastic wrap or balloon.
4. Place the eardrum model near speakers or headphones and play loud music. You should be able to see the salt or sand jump and vibrate. Does some music work better than others to vibrate this eardrum model?

In your science notebook, sketch and write about the following questions:

1. **Build** each model and test them. Sketch them.
2. **Similarities**: What do these models have in common?
3. **Differences**: What are some differences between these two models?
4. **Improvements**: What would you add or change about the model to make it better?

Comparing Eardrum Models

Kids Health Eardrum Model

https://kidshealth.org/en/kids/experiment-eardrum.html

Materials

- Glass bowl
- Plastic wrap
- 20 grains of uncooked rice
- Cookie sheet

Directions

1. Stretch a piece of plastic wrap over your bowl. Make sure the wrap is on there tight. The plastic wrap represents the eardrum.
2. Place about 20 grains of uncooked rice on the top of the plastic wrap.
3. Now you need some noise. Hold the cookie sheet close to the plastic wrap. Hit the cookie sheet to create a "big bang" noise and watch the rice grains jump. Now you know how sound causes your eardrum to vibrate, sending messages to your brain about the sounds you're hearing!

Science Friday Eardrum Model

https://www.sciencefriday.com/educational-resources/make-a-model-eardrum-to-detect-sound-waves/

Materials

- Plastic soda bottle or rigid plastic cup
- Rubber band
- Balloon or plastic wrap
- Sugar, salt, sand, or other sand-like substance
- Scissors
- Smartphone, small speakers or earbud headphones

Directions

1. Carefully cut the bottle or cup to make 5 centimeter ring cylinder shape.
2. Stretch the balloon or plastic wrap over one end of the ring. Make sure it is pulled tightly. Secure with rubber band.
3. Sprinkle the salt, sand, or sand-like substance on top of the plastic wrap or balloon.
4. Place the eardrum model near speakers or headphones and play loud music. You should be able to see the salt or sand jump and vibrate. Does some music work better than others to vibrate this eardrum model?

In your science notebook, sketch and write about the following questions:

1. **Build** each model and test them. Sketch them.
2. **Similarities**: What do these models have in common?
3. **Differences**: What are some differences between these two models?
4. **Improvements**: What would you add or change about the model to make it better?

Lesson 3 Decibels at a Distance

Purpose

In this lesson, students observe that sound goes out in all directions from a source by collecting and analyzing data from the sound of an airhorn to identify the relationship between the distance from a sound and how loud the sound is. Students learn about how to measure the intensity of a sound using a decibel meter and propose explanations of patterns in the data using ideas about sound energy and how sound travels.

This lesson provides some new information to students through non-fiction text, paired with a physical experience to help students make sense of how the singer could make such a loud sound. For more about supporting ongoing changes in student thinking, see http://AmbitiousScienceTeaching.org

Learning Target

Focus Question

What happens to the volume of a sound as we increase our distance from it?

Learning Target

I can collect and analyze data to make claims about how sound changes as we move farther away from it.

**You do not need to post a target statement. Instead, pose a question on the board.*

NGSS 3-D

SEP: Use mathematics and computational thinking *Measure and graph quantities to address scientific and engineering questions and problems.* **SEP: Analyzing & Interpret Data** *Analyze and interpret data to make sense of phenomena using logical reasoning* **PS3.A: Definitions of Energy** *Energy can be moved from place to place by moving objects or sound* **CCC Patterns** *Similarities and differences in patterns can be used to sort, classify, analyze rates of change for natural phenomena*

Materials

For the class:

- Chart paper, markers, sticky notes
- Trundle wheel
- 16-20 plastic cones, 5-6 different colors
- Air horn or sound generator

For each small group of students:

- 1 decibel meter
- colored pencils

Per student:

- 1 half sheet reading (link)
- 1 quarter sheet data table (link)
- 1 pair earplugs per person
- Science notebook

Teacher Preparation:

Set up the field. Borrow cones from P.E. Use a trundle wheel to measure off and mark distances with cones. If possible, color coordinate cones with locations (see map on next page)

Envisioning the lesson:

See and hear what pieces of this lesson might look/sound like with students. Here are videos from a summer mini-unit:

- 11 mins intro before collecting data
- 5 min small group talk after analysis

Lesson Step Summary

Part 1: 50-55 minutes *(If you need two shorter times, split after step 2).*

1. **Frame:** Connect to a student question/idea about loudness or volume
2. **Mini-Lesson:** Read about decibels. Explore how to use the decibel meter.
3. **Explore**: Collect volume data at different distances from a sound source
4. **Summarize:** Creating a data map. Use readings from each cone.

Part 2: 45-50 minutes *(If you need two shorter times, split after step 2).*

1. **Frame**: Examine data map as a class. What patterns do you see?
2. **Mini-Lesson**: *Choose based on need:* (a) What do scientists do with unexpected data points? or (b) How can we explain patterns in our data?
3. **Explore**: Modeling to explain data patterns with small group discussion.
4. **Summarize**: Select and sequence sharing of models. Compare ideas.

Part 3: 20 minutes

- **Summarize**: Create summary chart capturing data, information about decibels, explaining the data, and connecting to the phenomenon

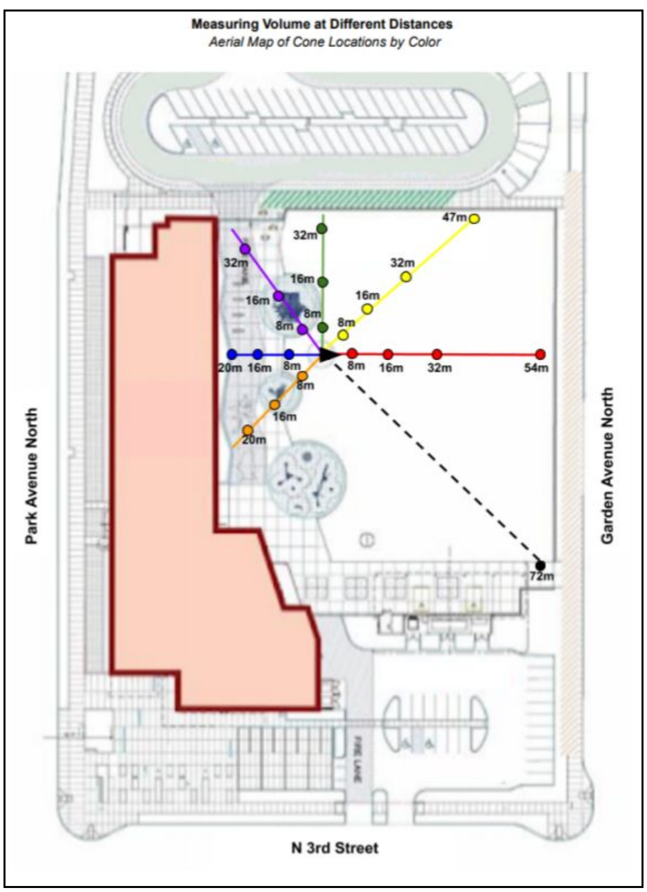
Teacher Preparation: Setting up the Cones

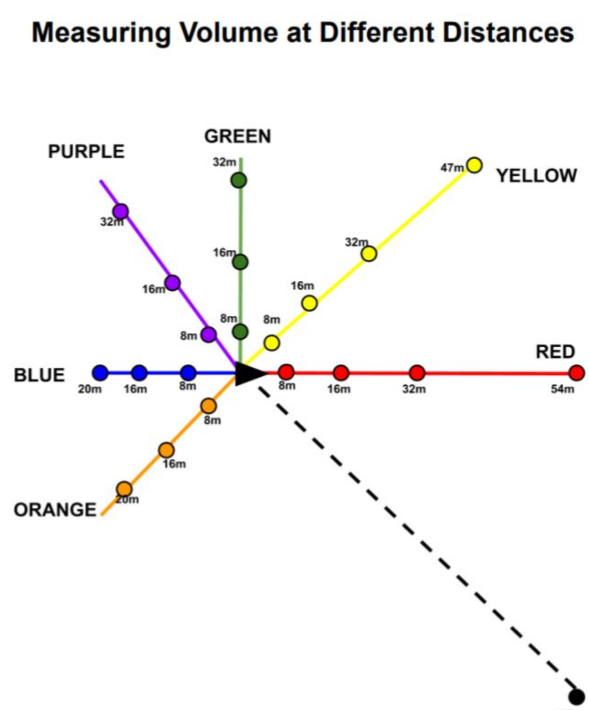
This data collection is designed to be done outside so check the weather forecast. If you must do this inside, select a different noise maker such as a vacuum cleaner (an air horn is too loud for indoor use) and different distance increments.

To set up outside: Bring cones and trundle wheels out to the playfield. Use a trundle wheel (clicks every meter) to measure off distances of 4, 8, 16, 32, and ideally 64 meters away from the source of the sound in several directions. Depending on the size of the playfield, make adjustments to the distances. In the example below, students standing on the blue line directly behind the airhorn only took measurements at 8, 16, and 20 meters before they ran into a wall.

Management Tip: If possible, color coordinate cones so each group of students can collect data at different points along that line color (i.e. table 4 is the blue group and collects on blue line).

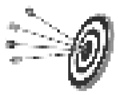
Maps that provide some context (like the map below, on the left) is helpful for students to use after collecting data and analyzing patterns. GoogleMaps can help get an aerial view of your playfield/school campus. The location of walls, structures, and open spaces might help them create conjectures to explain the patterns in their data. The map on the right shows the direction of the air horn (black arrow) and distances around. Labeling each color with the word helps for any students who are colorblind and for printing black-and-white copies of the maps.





Part 1: Learning about decibels and collecting data

1. Framing: Orienting students to today's concept(s).



Purpose

a) Open with a statement setting today's purpose and connecting to student's observations and ideas about the volume of the singer's voice and/or that the singer had to be close to the class. Tell students that today they will learn more about how sound changes as we get farther away from it.

Turn-and-Talk

b) Read today's focus question: *What happens to the volume of a sound as we increase our distance from it?* Have students think, pair, share about the focal question: *What happens to the volume of a sound as we increase our distance from it?* If desired, provide a context of someone whispering in the classroom and moving farther away from them.

Optional good listener challenge:
Give students the challenge of being a good listener. Spend a quick minute asking what a good listener might say or ask the speaker to show they were listening. Give this challenge for the partner talk. After the turn and talk and discussion, ask if anyone has examples of something someone did to show they were really listening.

This might sound like:

Last class, we learned about what parts work together inside our bodies to help us and the singer make powerful sounds. Today we will continue thinking about the volume and power of sound and what happens to it over a distance. When we first watched the singer video, we noticed (point to observation chart) *that the singer had to be loud and had to be up close to the glass. So our question today is: What happens to the volume of a sound as we increase our distance from it?*

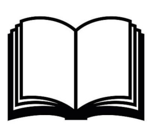
Let's think about the whispering we did the other day. If I'm whispering, who can hear me? What happens if you are farther away from me? Think about what happens to a sound as we get farther away from it [10-15 second think time] *Turn and talk with a partner.* [Time for turn-and-talk. Listen in on talk.]

I heard many of you say that you wouldn't be able to hear it anymore if you were far away or if there were things in the way, like walls or doors. Today we will learn more about how sounds change over distance. Before we collect data outside, let's read a little bit about the intensity or force of sounds and how we can measure sound. [Transition to reading task.]

2. Just-in-Time Instruction: Read, discuss, & explore decibels

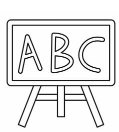
Mini-Lesson

a) Introduce new content about decibels and measuring the intensity of sounds by reading a short informational text.



Read for information

b) After reading, come together to review the new term (decibel) and why knowing about decibels is important. Spend a few minutes looking at text features and digesting the meaning of both of the diagrams.
- *What are decibels?*
- *Why do you think it is important to know about decibels?*
- *What do the diagrams tell us?*



New Term

Have students tape or glue the reading in their notebooks so they have it for future reference.

☑ **Teacher consideration**:
Decide how to structure the reading task. A few possibilities:

- *Individual*: Students read on their own. Write a sticky note to bring to the class.
- *Partner*: Students whisper read with a partner. Write a sticky note together to bring back to the class discussion.
- *Preview & Review*: Preview text as a class. Look at diagrams. *What are decibels? Why are they important to know about?* Spend 2 minutes previewing, then students read for 5 minutes before reviewing information together.

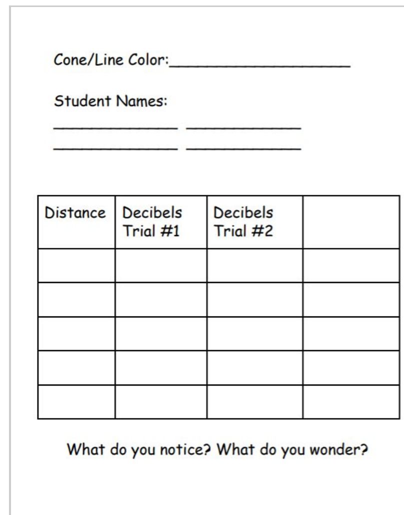

Measuring Tool

c) Pass out one decibel meter to each group. Have students take turns exploring it and making and measuring different sounds. After a few minutes of exploring, come together as a class, ask students what they figured out. Be sure to point out a few features if they don't come up:

- Look at decimal point (81.9 not 819).
- How to use the MAX button.
- How to reset the meter to take a new MAX reading for a second trial.

3. Explore: Collect Data

Tell students they will collect data about the volume of the air horn at different distances from it.


Cone/Line Color:___________________

Student Names:
_____________ ____________
_____________ ____________

Distance	Decibels Trial #1	Decibels Trial #2	

What do you notice? What do you wonder?

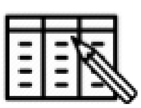
Before going outside:

1. Show students the map and assign each group to a position/color so each group knows where to start and where to move.
2. Set up (or use prepared) data tables to record measurements.
3. Review procedure for taking a MAX measurement and resetting the meter.
4. Make sure every group has a data table
5. **Safety alert!** Make sure each person has a pair of earplugs and puts them in!


Safety Alert

Go outside and collect data measurements at different distances away from the sound source.

4. Summarize: Create data map with measurements from each group.


Record data

Return to the classroom and add measurements to a class data map (see next page for example). If students have measurements that are unexpected you can discuss this now, if time permits, or during the next part of the lesson.

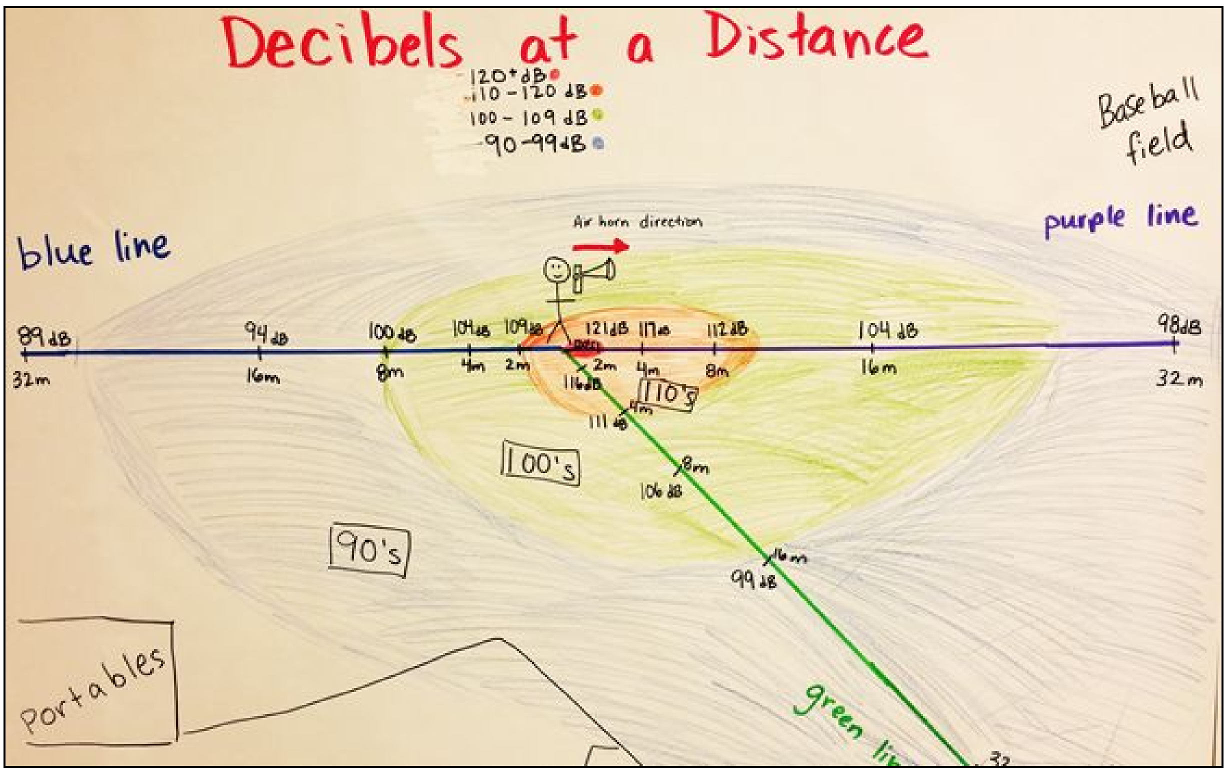

Quick Write

Have students do a silent quick write in their notebooks about today's focus question using their observations from today's investigation using information from the reading. *What happens to the volume of a sound as we increase our distance from it?*

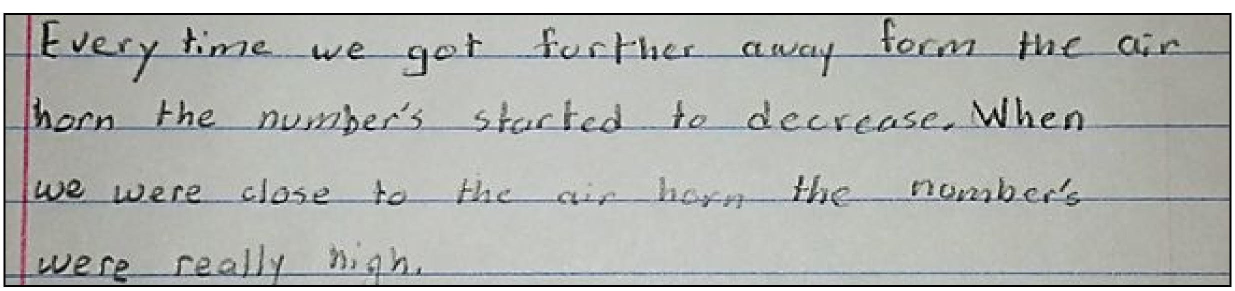
Take 1 minute for science notebook housekeeping (tape loose papers, fold pages over so they don't stick out, title, date, etc).

Photos from Part 1


Students outside on the field collecting data measurements.



Class data map example.



Every time we got further away form the air horn the number's started to decrease. When we were close to the air horn the number's were really high.

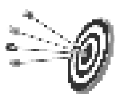
Student example from the quick write at the end of the lesson. This quick write could instead function as an opening "do now" entry task in part 2 to get students thinking about this data at the start of that lesson part.

Part 2: Analyze Data

1. Framing: Orienting students to today's concept(s).

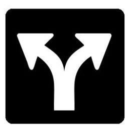

Turn-and-Talk

Open with students looking at the data map from Part 1. Have students think about some noticings and wonderings. Turn-and-talk. Listen in for some wonderings to use in the mini-lesson today to be responsive to students questions around data analysis or explanation.


Purpose

Tell students that today they will continue working on the question *What happens to the volume of a sound as we increase our distance from it?* by analyzing the data they collected and explaining how or why they think these patterns happened.

2. Just-in-Time Instruction: Data Analysis


Teacher Decision Point

Teacher decision point: Decide on one focus (a or b) based on what you observe from Part 1 and the prior turn-and-talk.
- a. Do students have some unexpected data points and need to figure out what to do with them?
- b. If data points seem reasonable, are students ready to identify patterns and work on explaining how/why they think those patterns happened?


Analyze data


Turn-and-Talk

a. Resolving unexpected data points:
- What data points seem unexpected or unusual?
- What might have happened that caused the unusual data point?
- What should we do? Do you think it is fair to throw it out? Why or why not? What should we do?
- Once resolved, move into identifying and explaining data patterns.

b. Identify & explain patterns:
- Jot a list of patterns students noticed on the board.
- Have students pick a pattern. Think about how/why they think that happened. Turn-and-talk.
- What representation of sound from our list (L1) would you use to help explain what sound is doing to cause that pattern?

3. Explore: Model-to-Explain patterns in the data


Model to Explain

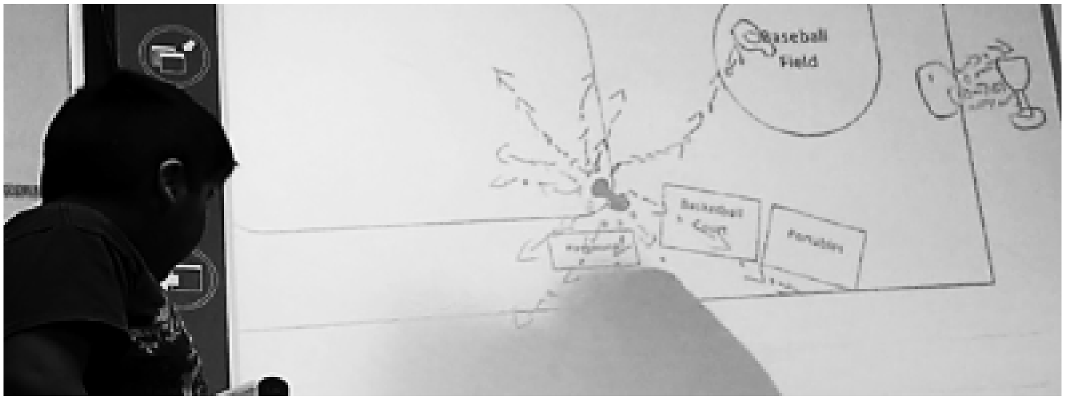
Tell students that they will now have a few minutes to develop a model showing the sound from the airhorn and what it is doing that explains one or more of the data patterns/noticings. Students sketch in their notebooks or use this ⅓ sheet template. Refer students to the representations of sound chart created in L1. As students work, circulate and look for ways students represent volume and how or why volume changes.

4. Summarize: Sequenced share with discussion

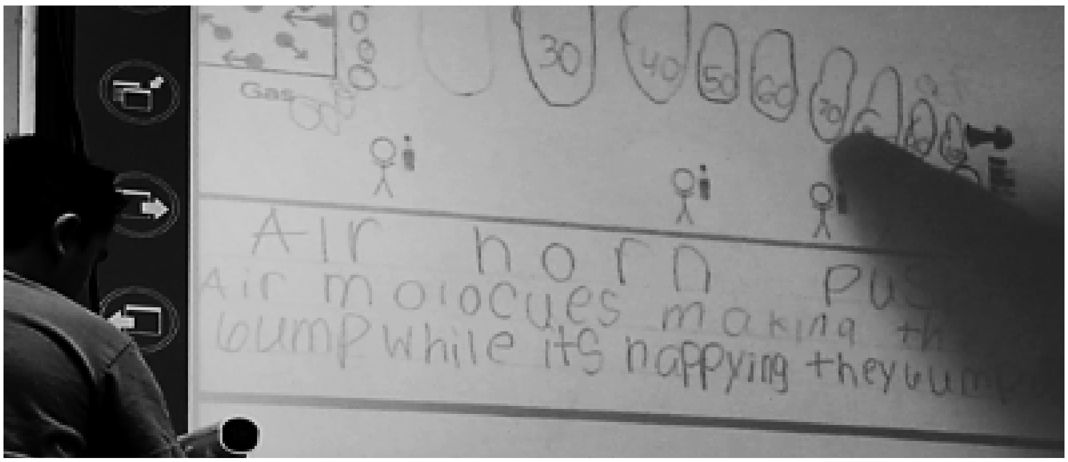

Share & Discuss

Select 2-3 models to share whole class to open a discussion about what students think is happening to the sound over a distance. How are students representing volume? Which sound representations help communicate patterns in data that volume decreases with distance? Students may bring up wind (if it was a windy day) or if wind and sound are the same. Jot notes for yourself to plan/revise upcoming lessons to be responsive to students' ideas.

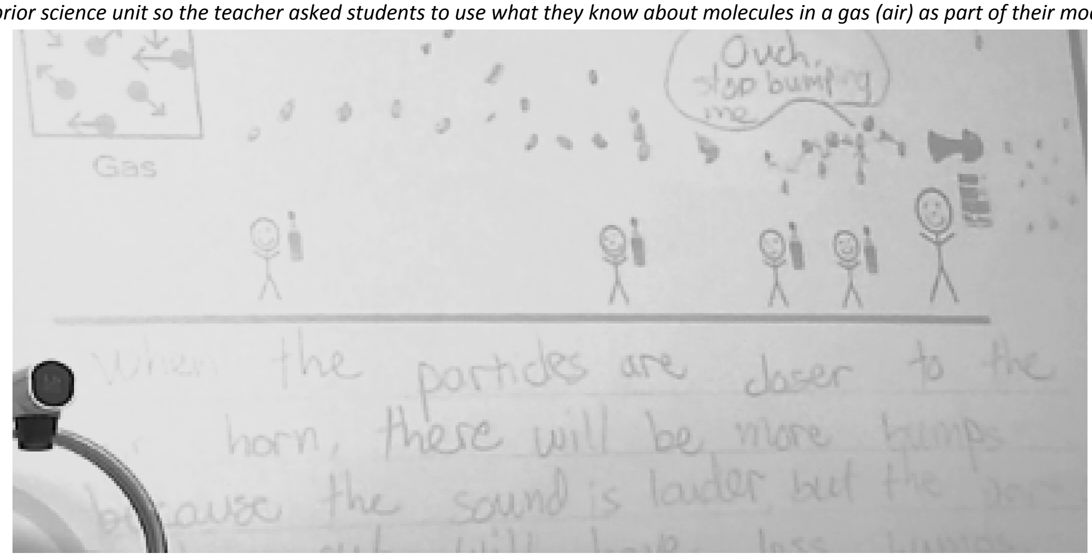
Photos from Part 2



Brando shares his model showing sound going in all directions from a birds eye view. Students agreed with this because everyone could hear the air horn. The teacher added this to the summary chart under observations ("Sound goes out in all directions from the source").



Isai shares his model focusing on how sound affects air molecules. He drew different bubbles of volume decreasing over a distance. He wrote: Air horn pushes air molecules making them bum while its happying (happening) they bump. *[Students knew about molecules from a prior science unit so the teacher asked students to use what they know about molecules in a gas (air) as part of their model.]*



Joseph uses his knowledge of molecules in the air to focus on sound as energy bumping into molecules. He wrote: When the particles are closer to the air horn, there will be more bumps because the sound is louder but the bumps will bump less bumps farther away.

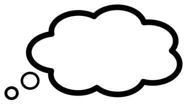
[Note: If students are not yet bringing up ideas about air molecules, they will get more information about molecules in upcoming lessons. It is important students are building their understanding, not just regurgitating facts about states of matter. Students are more likely to not bring up molecules here unless they have some prior background knowledge -- knowledge they will get information about in upcoming lessons.]

I obseverd 3 thing that we did with the Air horn on the feild.
The first thing I observed is that when we were at the 32M that was strat towards the air horn we got 88.9 but what I notesst is that there was another 32M not going strat towers the air horn so when we measured from that 32M mark we got 81.4.
Now that what trend the table's becouse the both the same measurement but different results.
So here is what I think might be afecting the diffrence in the measurement of the 32M is mabey the different distence.
See, there both meaured as 32M but there both a differet distence.
The first 32M that measured 88.9 that distence was strait towards the air horn and the 32M that was 81.4 wasent striat towards the air horn becouse the air horn was pointing a different direcion.
And that bring's me to my observation on angle and I asked my self "dose the angle we were faceing afect the way the sound of the air horn gose"?
And other thing is that we had alot of sound around use so that could have afected the measurement.
one more thing is that every time we went farther and father back it was kinda like [illegible]

In another classroom, students had a 10 minute time for science the following day because of an assembly. The teacher knew this would not be enough time to have a summarizing learning discussion so the teacher added a quick-write asking students to write about their observations and current thinking of the connection between decibels and distance using specific data points. This is one example from a student notebook of student thinking about what trends in the data mean and how data can foster new questions (i.e. "Does the angle we were facing affect the sound?")

Part 3: Summarizing Learning

Summarize: Create a summary chart or add to summary table.



Think Time

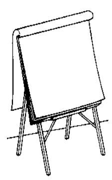
A. Individual think time & group discussion.

Have students take a few moments to think and/or jot some notes about each column. Give think/jotting time first and then a few minutes of discussion one column at a time, spending the most time on learning and connections.

Investigation	Observations	Learning	Connections
What did we do? What were we figuring out?	What did we observe? What patterns did we notice in the data?	How can we explain patterns in the data? What did we learn about decibels? What questions do we still have about our data?	What does this have to do with explaining why the singer was able to shatter the glass?

Share & Discuss

Circulate and listen. If there are ideas you want students to bring up whole-group, say something like, “I hear you talking about X. Would you remember to bring that up when we discuss this as a whole group?”

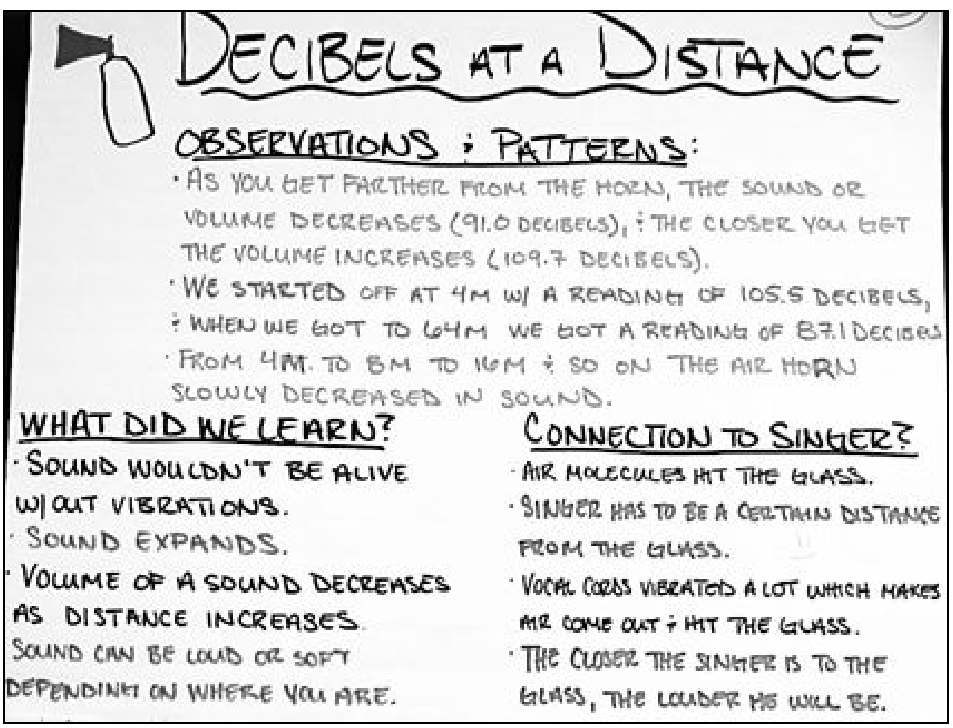


Summary Table

B. Summarize: What’s important to remember?

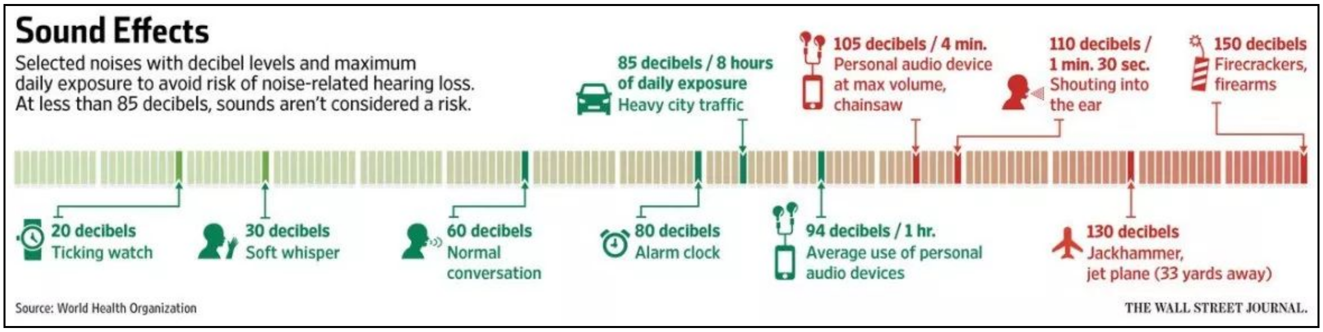
Share some ideas as a whole class that small groups talked about, Then, use some think time and pair-shares to decide on: What information should we put on our summary chart to remember for later? What do we think is important about what we did? observed? and learned today? Are we able to answer our focus question? How does knowing about decibels, distance, and volume help us explain how the singer could shatter the glass?

Photo from Part 3

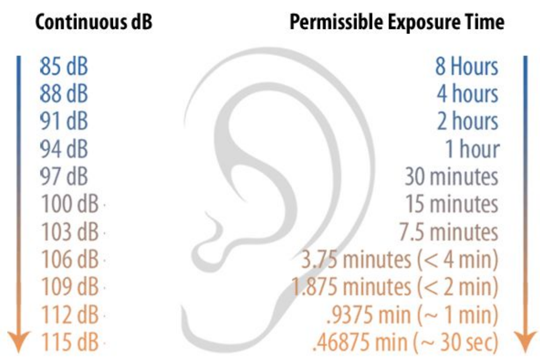


Measuring Sound

We can measure the intensity or loudness of sound by using a tool that measures **decibels**. Decibels measure the pressure or forcefulness of a sound wave. The more pressure a sound has, the louder the sound is. The decibel measurement works on a power of ten. This means that a sound at 100 dB is not just ten decibels louder but *ten times louder* than a sound at 90 dB.

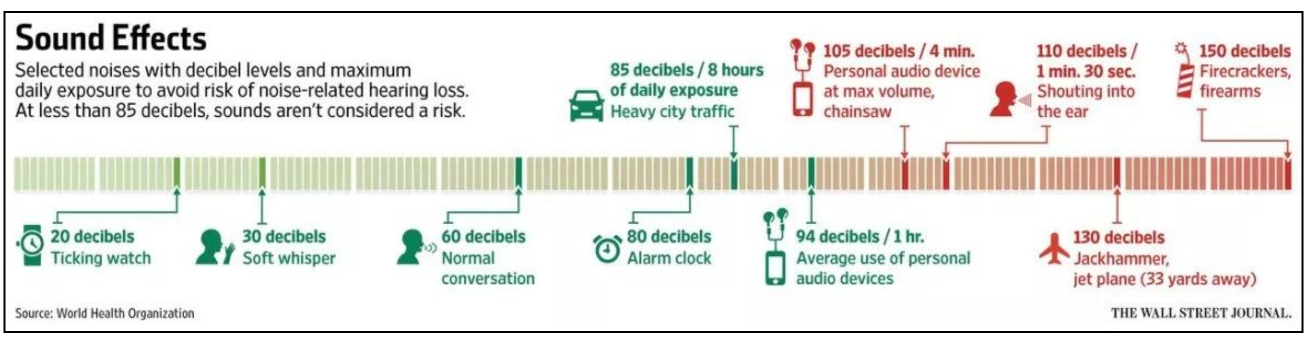


Whether a loud sound will damage your hearing or cause hearing loss depends on two factors: (1) how loud the sound is, and (2) how long the loud sound lasts. Any sound around 85 decibels can cause hearing loss after several hours. For example, working an eight hour shift in a noisy environment at 90 dB can cause permanent damage. Sounds at 140 decibels, like standing next to a jet airplane taking off, can instantly cause damage. Blasting really loud music into your headphones is a fast way to damage your hearing. It might not happen right away, but over time, you may notice changes to your hearing.

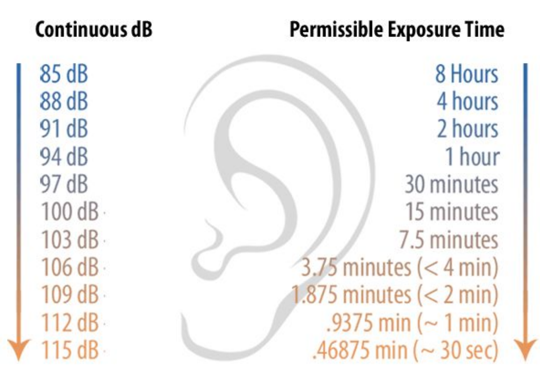


Measuring Sound

We can measure the intensity or loudness of sound by using a tool that measures **decibels**. Decibels measure the pressure or forcefulness of a sound wave. The more pressure a sound has, the louder the sound is. The decibel measurement works on a power of ten. This means that a sound at 100 dB is not just ten decibels louder but *ten times louder* than a sound at 90 dB.



Whether a loud sound will damage your hearing or cause hearing loss depends on two factors: (1) how loud the sound is, and (2) how long the loud sound lasts. Any sound around 85 decibels can cause hearing loss after several hours. For example, working an eight hour shift in a noisy environment at 90 dB can cause permanent damage. Sounds at 140 decibels, like standing next to a jet airplane taking off, can instantly cause damage. Blasting really loud music into your headphones is a fast way to damage your hearing. It might not happen right away, but over time, you may notice changes to your hearing.



Student Reading, Lesson 3: Decibels at a Distance

Cone/Line Color:____________________

Student Names:

______________ _____________

______________ _____________

Distance	Decibels Trial #1	Decibels Trial #2	

What do you notice? What do you wonder?

Cone/Line Color:____________________

Student Names:

______________ _____________

______________ _____________

Distance	Decibels Trial #1	Decibels Trial #2	

What do you notice? What do you wonder?

Cone/Line Color:____________________

Student Names:

______________ _____________

______________ _____________

Distance	Decibels Trial #1	Decibels Trial #2	

What do you notice? What do you wonder?

Cone/Line Color:____________________

Student Names:

______________ _____________

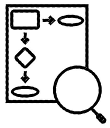
______________ _____________

Distance	Decibels Trial #1	Decibels Trial #2	

What do you notice? What do you wonder?

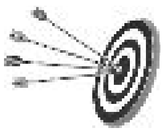
Reflections & Notes

Engineering Design   Noisy Place Problems   Part A



Purpose

In this lesson, students put into practice some of the science ideas they have been thinking about related to force, volume, hearing safety, and distance from a sound. In Part A of the "Noisy Places" engineering project, students identify a noise problem, design a data collection process, and collect and analyze data to assess the scope of the problem. In Parts B and C later in the unit, students design a solution and test prototypes to solve this sound-related problem. The data students collect in Part A can serve as a baseline for when they test their prototypes later.



Learning Target

Focus questions

What are some noise problems in our school community?

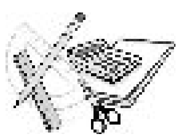
Learning Target

I can plan an investigation and collect data from a noisy place with my group.

**You do not need to post a target statement. Instead, pose a question on the board.*

NGSS 3-D

SEP: Ask Q's & Define Problems *Define simple problem solved by tool, process, system; addresses criteria & constraints* **SEP: Plan & carry out investigations** *Make observations to produce data to serve as basis for evidence*
PS3.A: Definitions of Energy
LS1.D: Information Processing
Influence of STEM on Society & Natural World *Engineers improve existing technologies or develop new to increase benefits, decrease known risks, meet societal demands.*



Materials

For the class:

- News video (link)
- Chart paper, markers, sticky notes
- assorted materials students likely need for collecting data (decibel meters, string, meter sticks, trundle wheel, timer, stopwatch, etc.)

For each small group of students:

- 1 decibel meter
- 1 Chromebook or computer

Per student:

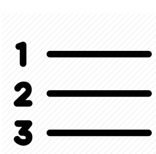
- Science notebook and/or a copy of the Noisy Problems planning pages

☑ Teacher Preparation: Considering Student Groups

Students will work in groups of 3-4 to plan and conduct their investigation. This lesson is written as if students already know their groups. Another option is having students group up based on the problem they want to investigate.

☑ Teacher Preparation: Schedule for data collection

Be flexible with your schedule to meet groups' data collection needs. If your schedule is not flexible, let students know this in Part 2 as a constraint (i.e. data has to be collected 2:15-3:00 PM).



Lesson Step Summary

Part 1: 45 minutes Explore & Brainstorm

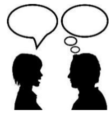
1. **Frame:** Connect to prior learning and begin thinking about noisy problems
2. **Mini-Lesson:** Read/watch Nora's example noisy problem investigation.
3. **Explore**: Brainstorm noisy place problems. Each group decides on one.
4. **Summarize:** Personal reflection on group negotiations.

Part 2: 45 minutes Plan data collection

1. **Frame**: Review Nora's noisy problem investigation with hand dryers.
2. **Mini-Lesson**: Use Nora's investigation as an example to talk about data.
3. **Explore**: Groups decide on a data collection plan using available materials (decibel meter, yard/meter stick, timer, clock, etc)
4. **Summarize**: Troubleshoot and workshop data collection plan(s).

Part 3: 45+ minutes Collect and Analyze Data

Part 1: Brainstorm sound-related investigations & noisy place problems



Turn-and-Talk

1. Framing: Orienting students to today's concept(s).

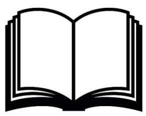
Recap prior learning around how we create and receive sound signals, vibrations, decibels, etc. Refer to the summary charts. Set today's purpose as brainstorming and identifying some noise-related problems in our community. Ask today's focus question: *What are some noisy place problems in our community?* Have students think, pair, share about the question.

Watch

2. Just-in-Time Instruction: Examine a noisy place investigation

Introduce the idea of planning and conducting an investigation about a sound-related question by using a project by eighth grader Nora Keegan. Watch news video: NBC KFDX News (1:51) Read article(s):

- CNN news article
- Paediatrics & Child Health (Use the abstract or whole article)



Read

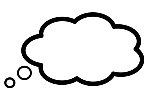
Discuss:

- What question was Nora Keegan wanting to answer?
- Why do you think Nora wanted to investigate this question?
- What did Nora find out? Were you surprised with the results?
- How did Nora collect data? What data did she collect?
- What questions do you have related to sound and/or her investigation?

Discuss

3. Explore: Brainstorm noisy place problems with your group

Today they will have time to brainstorm problems or questions about sound with their in group. This prompts/task sequence might be helpful:



Think Time

- **Individual Brainstorm**: *What are noisy places around the school?*
  Jot a list of places in and around your school you know are noisy places. Circle any places where you think the noise is a problem.
- **Team Compare**: *What places do you have in common?*
  Take turns reading lists. If you hear a place you also have, put a check mark next to it.
- **Decide on the location and problem**. Discuss places you agree are noisy. What places are noisy? Where is noise a problem?
  Decide on one place and problem you want to investigate as a team.
- **Get teacher feedback or approval.** Be prepared to tell your teacher about the problem your group identified.
  If approved, begin making a plan for your data collection until time is up for today.
  If not, your teacher will give you feedback to address as a team.

Teamwork

If multiple groups decide to investigate the same noisy place problem (i.e. noisy stairs after lunch/recess bothers nearby classrooms) that is a benefit in Parts B & C to compare and test multiple solutions to the same problem

Quick Write

4. Summarize: Share ideas and personal reflection.

Do a quick whip-around share for each group/team to share their location and problem so everyone hears. Take a few moments for students to reflect on how they did today in working with their team. What did they do well? What can they work on to be a better teammate? Could be a quick write or a quiet, personal think time.

Part 2: Planning data collection

Purpose

1. Framing: Orienting students to today's concept(s).

Tell students that today they will continue working on planning their sound investigation with their group by negotiating what kind of data your group needs to answer your question.

Turn-and-Talk

2. Just-in-Time Instruction: Data Collection

Revisit the project by eighth grader Nora Keegan from Part 1. Have students turn-and-talk: *What did Nora want to figure out in her investigation?*

Watch

Read

Today focus on the data or measurements Nora collected, how she collected it, and where she collected it. Have students use the video and article(s) to skim to find information about her data and data collection.
News video: NBC KFDX News (1:51)
Articles: CNN news article or Paedeatrics & Child Health (Abstract or article)

Discuss

Locate & discuss:
- What data did Nora collect? How did Nora collect this data?
- How many different dryers did she test? Why do you think she tested so many dryers?
- Do you think the data measurements she collected helps answer her question? Why or why not?
- *Optional*: *If you repeated Nora's experiment, what other data would you want to collect?*

Mini-Lesson

Tell students key points about data collection. If needed, connect to recent experiences to further discuss or give examples for each point.
Students keep these in mind as they go back to their planning pages to plan data collection with their groups.

Think Time

- Scientists collect data to answer their question. **How do you know if the data will help answer the question?**	*Refer to Nora's project and also the recent Decibels at a Distance lesson for examples about how data matches the question to help answer it.*
- Scientists collect different kinds of data, such as measurements or survey responses. **What type of data will help answer your question?**	*Show students the materials you have available for them to use. If students want to use something else, borrow from another class, teacher, or bring from home.*
- Scientists collect enough data or repeat a test enough times to feel confident in data patterns, but... **How much data is enough?**	*Refer to recent experiences to reflect on the number of measurements per location. Did students think they had enough measurements to draw conclusions? By the end of this lesson, students need to provide a reason for why they choose the number of data points or tests they need.*

Think Time

3. Explore: Negotiate a data collection plan with your group

Tell students that they have a few minutes to jot their ideas about data for their investigation before negotiating with their groups. Their goal today is to decide on plan - What data do they need to collect? How and when do they need to collect it? (Optional: Have students remind themselves of something they are working on to be a productive member of a team before starting the team discussion.)

Teamwork

As groups discuss their plans, circulate and listen in. Students will enact their data collection plan in Part 3 so make sure their plans are reasonable given the materials you have and in a timeframe comfortable for your class.

4. Summarize: Troubleshoot & Workshop Plans

Share & Discuss

Use this 5-10 minutes to be responsive to the data collection plans you observed. It is likely that at least one group might feel stuck and could use some input from others about how to resolve conflicts or how to collect the "right kind" of data for their question. Invite or have group(s) volunteer for some whole-class workshopping of their data collection plan. .

Make sure each group has the materials they need or students know where to locate them for Part 3.

Part 3: Collecting Data

Collect Data

Give students time to collect data for their question (Part 3. Collect your data). This time may not be during your regularly scheduled science block. For example, students may need smaller blocks of time over a few hours, such as during other grade levels' lunch or recess if they were interested in sound levels in the cafeteria, playground, or stairs at different times of the day.

Analyze data

After students have collected their data, have groups analyze their data:

- What patterns do you notice?
- Do you have any unusual data points?
- What do you think might have happened to cause these patterns?
- What questions or wonderings do you have now?

Share & Discuss

Share and discuss any interesting findings or patterns. This could be a stay-and-stray (where some members stay with their data, and others stray to go to other groups to hear/see about their data) or in a whole class discussion format.

Quick Write

Allow students a few minutes of individual processing time to do a quick write about their data collection, analysis, wonderings, and potential causes to these noisy problems.

Have students keep their data in their science notebooks or other safe place. They will need this data as justification for their prototype plans during Part B of the Noisy Places Engineering Design Challenge.

Some kids say hand dryers hurt their ears. A Canadian girl conducted a study about it.

By Evan Simko-Bednarski, CNN

Updated 12:58 PM ET, Mon July 8, 2019

A Canadian eighth-grader's science experiment raises questions about whether hand dryers, like the ones found in public restrooms around the world, can damage the hearing of young children.

The study, published last month in the journal Paediatrics & Child Health, also indicates that some manufacturers' stated noise ratings might be nothing but hot air.

Calgary, Alberta, eighth-grader Nora Keegan started with some anecdotal evidence.

"Informally, parents have said that their children refuse to go into particular washrooms because the dryers are too noisy, and children say they 'hurt my ears,' " Nora wrote.

Her approach for testing this hypothesis, however, consisted of the kind of scientific rigor that peer-reviewed publication demands.

Using a decibel meter, Nora measured the peak loudness of 44 public-bathroom hand dryers from several positions. She positioned the meter to simulate the average ear height of a 3-year-old, an adult male and an adult female as well as her height at the beginning of the study: just over 4 feet. She also measured the loudness at the dryer's air jet.
She waited to measure until there was no ambient noise in the restroom and made sure there was no wind. She measured the noise level both when the dryer clicked on and while there were hands in the stream.

In total, Nora took 880 measurements.

She evaluated those measurements by two standards: US Environmental Protection Agency guidelines, which recommend hearing protection for children at noise levels higher than 85 decibels, and a 2016 study in an Indian pediatric journal showing that a child's sudden exposure to noise above 100 decibels can lead to learning disabilities and hearing damage.

Nora Keegan took 880 measurements for her hand dryer study.

In the end, of the 23 models of hand dryer that Nora encountered in the wild, a single dryer manufactured by Comac was consistently quieter than 85 decibels at all positions. Others were below 90 decibels but still above the EPA's threshold.
The most common hand dryers in Nora's study, those manufactured by Dyson and Xlerator, were also the loudest.

"All Xlerator models, the Blast, and the Dyson Airblade and Airblade V models were louder than 100 dBA when hands were in the airflow, for all measurements," she wrote.
Her findings were also significantly above the noise levels reported by the manufacturers themselves.

"The Xelerator readings were far above their stated operating loudness of 70 to 80 dB," she wrote. Two out of the three of a particular Dyson Airblade model were above 105 decibels when measured at the height of a 3-year-old, according to Nora, "four times the loudness claimed by the manufacturer and a level dangerous to children's hearing."

However, she suggested that the real-world conditions of a public restroom might not match the conditions under which the dryers are tested in the factory, given a bathroom's "increased echoes."

She also acknowledged the limitations of her study: "For many dryer models, only one device was found installed in public washrooms. If one of these performed loudly, it does not mean all machines of the same model would be equally loud."

In a statement to CNN, Dyson said it welcomed Keegan's work.

"Dyson's philosophy is about using science and engineering to solve problems," reads the statement shared by Dyson spokeswoman Katie Doan. "So we're delighted to see Nora's work and we're looking to arrange a call between Nora and one of our acoustics engineers in the near future."

The Dyson statement said the company is "keen to show Nora how our latest hand dryers are significantly quieter than their predecessors," due to work by the firm's engineering team, a team they indicated Keegan might one day want to join.

Neither Nora nor Xlerator responded immediately to a request for comment.

Paediatrics & Child Health, 2019, 1–6
doi: 10.1093/pch/pxz046
Original Article

Original Article

Children who say hand dryers 'hurt my ears' are correct: A real-world study examining the loudness of automated hand dryers in public places

Nora Louise Keegan

Student, Grade 8, Calgary Board of Education, Calgary, Alta.

Correspondence: Nora Louise Keegan. E-mail norak5@educbe.ca

Abstract

Introduction: Previous research has suggested that hand dryers may operate at dangerously loud levels for adults. No research has explored whether they operate at a safe level for children's hearing. Children's ears are more sensitive to damage from loud sounds than adult ears. Health Canada prohibits the sale of toys with peak loudness greater than 100 dB. This study tested installed dryers in public washrooms to see if they were safe for children's hearing.

Methods: Forty-four hand dryers in public washrooms were each measured for peak sound levels in a standardized fashion, including at children's ear canal heights. Each dryer was measured at 10 different combinations of heights and distances from the wall, and with and without hands in the air stream coming from the hand dryer, for a total of 20 measurements per dryer.

Results: Xlerator units performed the loudest, with all being louder than 100 dBA at all measurements whenever hands were in the airstream. Several Dyson Airblade models were also very loud, including the single loudest measurement of 121 dBA. While some other units operated at low sound levels, many units were louder at children's ear heights than at adult ear heights.

Discussion: Many dryers operated much louder than their manufacturers claimed, usually greater than 100 dBA (the maximum allowable noise level for products/toys meant for children).

Conclusion: This study suggests that many hand dryers operate at levels far louder than their manufacturers claim and at levels that are clearly dangerous to children's hearing.

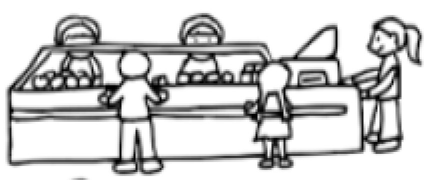
Keywords: *Hearing protection; Injury prevention; Public health*

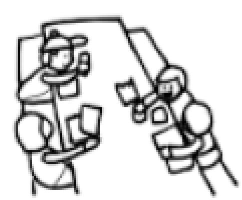
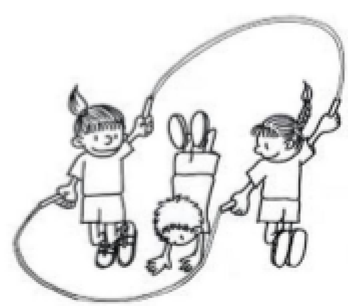
Reflections & Notes

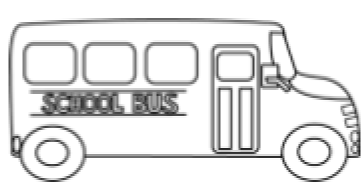
Noisy Places:

Finding Solutions to
Noisy Problems
in Our School Community

Name of Acoustical Engineer:



Part 1. Identify a Problem

1. Individual Brainstorm: *What are some noisy places around the school?*
Jot a list of places in and around your school you know are noisy places.
Circle any places where you think the noise is a big or important problem.

2. Team Compare: *What places do you have in common?*
Take turns reading your list of places in the box above.
If you hear a place you have also, put a check mark next to it.

3. Decide on the location and problem.
Discuss places you agree are noisy. What places are noisy? Is the noise level a problem? Decide on one place and problem you want to investigate as a team

We decided on…

Location:

Noise problem:

4. Get teacher feedback or approval.
Be prepared to tell your teacher about the problem you identified. If approved, move on to making a plan for your data collection. If not, your teacher will give you feedback you need to address as a team.

Part 2. Plan your Data Collection

1. Individual Brainstorm: *What data do you need related to this problem?*
Jot some ideas about what information you need about the problem. Will you need to measure the volume of the noise? Times of day? Interview some people?

2. Team Compare: *What data ideas do you have in common?*
Take turns reading your list of data collection ideas in the box above. If you hear a similar idea to what you wrote, put a check mark next to it.

3. Decide on the data you need to collect.
Discuss different kinds of data you need to collect and make a plan.
Write down what you and your group decide in the box below.

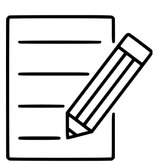
Data Source	When?	Materials needed	Why is this data important?

4. Get teacher feedback or approval.
Be prepared to tell your teacher about your team's data collection plan. If approved, your teacher will tell you when to start data collection. If not, your teacher will give you feedback you need to address as a team.

Part 3. Collect your Data

Use the space below to collect data about your noisy problem.
Work as a team. Be responsible. Every team member needs to record data.

Conclusions: *What does the data show about the noisy place problem?*



Individual Reflection: *Write about your data collection.*
- *Did it go smoothly? How did you solve any problems?*
- *Did any data surprise you? Did you double-check any measurements?*

Part 4. Identifying Potential Solutions

1. Individual Brainstorm: Look at the data from the noisy place you investigated in Part 3. *What are some possible solutions that would help reduce or stop the noisy in this place?* Jot as many different ideas as you can think of.

2. Team Compare: *What solution ideas do you have in common?* Take turns reading your list of potential solutions in the box above. If you hear a similar idea to what you wrote, put a check mark next to it. If you hear an idea you like, have the person put a heart next to it.

3. Decide on one solution to try out.
Discuss different solutions. Make some compromises. Decide on one as a group to try out. Use the next sheet to sketch out your plan with more detail. Summarize what you and your group decide in the box below.

Our Solution:

Why or how do you think this solution will meet the criteria?

Materials needed:

4. Get teacher feedback or approval.
Be prepared to tell your teacher about your team's proposed solution. If approved, your teacher will tell you when to start building your prototype. If not, your teacher will give you feedback you need to address as a team.

Part 4. Identifying Potential Solutions

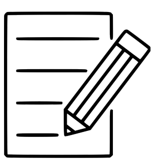
Space to sketch, label, describe, and justify your team's solution you will build and test.

Why do you think this solution will be successful in reducing noise?
Use evidence to justify your claims.

Part 5. Collect Data on the Prototype

Use the space below to collect data about prototype solution.
Work as a team. Be responsible. Every team member needs to record data.

Conclusion: *How well did the prototype work to reduce the noise?*



Individual Reflection: *Write about your prototype and test.*

- *Did the design work as well as you hoped? Why or why not?*
- *What changes might you make in the design to improve your prototype?*

Part 6. Evidence-based Proposal -- Notes Organizer

Describe the Problem: *What is the problem? Why is it a problem? For whom?*

Evidence for why this is a problem: *What data do you have to help describe the problem? What information do you have that says this noise level is a problem?*

Describe the Solution: *What solution did your team develop? Why did you think this solution should work? What evidence did you have that the materials or shapes you used would likely reduce sound?*

Evidence for why this solution works: *How well did the prototype work? What data do you have to support your claim?*

Next steps to improve the prototype: *What changes or improvements would you test next? What information or evidence do you have to support your proposed change?*

Lesson 4 Seeing Sound Waves

Purpose

In this lesson, students use water waves and tuning forks to visualize the relationship between an initial force creating the vibrations and energy of a wave. The harder the force to begin the vibration, the louder the sound, and the more energy it has (wave amplitude represents volume). Students will observe tuning forks and use them to make waves. Then, they will represent the relationship between volume and force to show that as force used to create vibrations increases, the amplitude (or height) of those vibrations increases and the volume also increases.

This lesson provides some new information to students through non-fiction text, paired with a physical experience to help students make sense of sound as energy. For more about supporting ongoing changes in student thinking, see [*http://AmbitiousScienceTeaching.org*](http://AmbitiousScienceTeaching.org)

Learning Target

Focus Questions

How does the amount of force change a sound wave?

Learning Target

I can make observations about force, vibration, and volume to develop models of wave properties. **You do not need to post a target statement. Instead, pose a question on the board.*

NGSS 3-D

SEP: Plan & carry out investigations *Make observations to produce data to serve as basis for evidence*

SEP: Analyzing & Interpreting Data *Analyze and interpret data to make sense of phenomena using logical reasoning*

PS3.A: Definitions of Energy *Energy can be moved from place to place by moving objects or sound*

Cause & Effect *Cause & effect relationships are routinely identified and used to explain change*

Materials

For the class:
- Summary chart, sticky notes, markers
- Representations of sound chart (L1)

Per group:
- 1 dish tub ½ filled with water
- 3 tuning forks
- Paper towels

Per student:
- Half-page reading: Amplitude (link)
- Half-page reading: Pitch (link)
- Science Notebook

Management Tip

Before Part 1, have a student help you to fill one dish tub per group half-way full with water. Leave them on a side table until needed. When ready, have students clear off the tables. Then send one person from each table to carefully carry one tub to their table group.

Lesson Step Summary

Part 1: Making Observations (45 mins)
1. **Frame:** Connect to an idea about sound waves or wave representations
2. **Mini-Lesson:** Read about amplitude. Explore how to use a tuning fork
3. **Explore**: Make observations about tuning fork vibrations in water.
4. **Summarize:** Quick write about observations.

Part 2: Developing Models and Summarizing Learning (45 mins)
1. **Frame**: Review observations from part 1.
2. **Mini-Lesson**: Representing properties of sound energy.
3. **Explore**: Modeling to explain why the waves eventually stop.
4. **Summarize**: What did we do? What did we learn? Connect to the singer.

Part 1: Learning about wave amplitude

Purpose

Observations

Turn-and-Talk

New Tool

1. Framing: Orienting students to today's concept(s).

a) Open with a statement connecting to a student's idea about the sound waves or energy if. Tell students that today they will learn more about how energy travels in waves by making waves visible in water.

b) Tell students to observe you use a tuning fork. Rotate the fork to tap one prong on the carpet and lift it to your ear. Repeat, but hit one prong harder on the carpet and raise to listen. Have students turn-and-talk.

c) Review the terms **force** and **vibration** students learned in the Human Systems lesson and apply it to the tuning fork. Students should notice that more force makes the vibrations stronger and the sound louder.

d) Pass around one tuning fork per pair and let students explore how to use them for a few minutes while at the carpet. Have students make observations with their partner about the amount of force, the strength of vibration, and the volume of the sound.

2. Just-in-Time Instruction: Waves move energy.

Mini-Lesson

a) Tell students about waves and energy. **Waves** move energy from place to place faster and farther than the wave moves matter. Have 4 students stand up in a line shoulder-to-shoulder. Gently push on one and watch what happens. Repeat but push a little harder. Ask the students how it felt.

- Did everyone feel the push? If the push was hard enough, everyone will feel it, and might have moved slightly. If not, the energy might only move through 2 or 3 students.
- Did the first student physically move all the way to where the last student is? No. The matter (person) moved a little but not as far compared to how far the energy (push) moved. The push is energy. It transfers in waves, kind of like doing the wave at a sports stadium.

New Term

Read for information

b) Read the short half sheet reading about amplitude. After reading, come together to review the new term (amplitude). Spend a few minutes looking at text features and digesting the meaning of the diagrams.

- *What is amplitude?*
- *Why do you think it is important to know about amplitude?*
- *What do the diagrams represent about sound?*
- *What does this reading have to do with the tuning forks are using?*
- *How does this information connect to the push demonstration we just did?*

Have students tape or glue the reading in their notebooks so they have it for future reference. If time permits, students could also read and learn about pitch: What is pitch?

3. Explore: Make Observations

Observations

Tell students they will use water to help them see the waves. Remind students how to tap one prong of the tuning fork on a soft surface to get the vibration started. Students can then listen to it to hear the volume or rotate the tuning fork to touch both prongs into the surface of the water to see the wave. Try hard hits and soft taps.

Back-Pocket Questions

Back-Pocket Questions:
- How can you make a louder volume? Softer volume?
- Why do you think hitting the tuning fork harder makes it sound louder?
- After you hit the tuning fork to start the vibrations, where does that energy go?
- What does the vibrating tuning fork do to the water?
- Why do you think more force make the water waves splash more?

Quick Write

4. Summarize: Quick write about observations.

Have students do a silent quick write and sketches in their notebooks about how waves move energy using the tuning fork in water example and their observations from today's investigation using information from the reading. *What causes waves? How do waves move energy? What did you notice?*

Take just 1 minute for science notebook housekeeping (tape loose papers, fold pages over so they don't stick out, title, date, etc).

*Optional Extension: Other Wave Properties

Extend & Follow-up

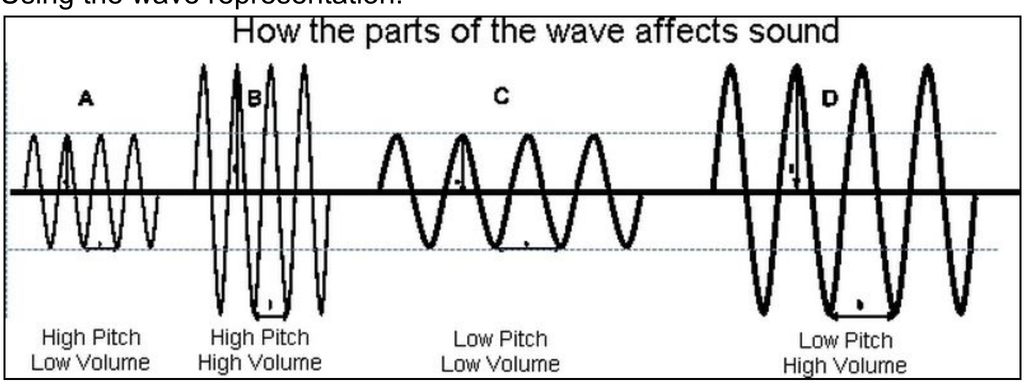
PS4.A Wave Properties includes properties of waves like wavelength, frequency, and amplitude. The prior lesson part focused on amplitude. If time permits, students can learn about other wave properties in an extension.

For more teacher content knowledge, read this and to see a visual explanation watch this Khan Academy video (5:15). It is far more information than upper elementary students need but it shows different wave properties.

Check out these websites for students to learn about properties of waves:
https://www.generationgenius.com/learn-different-types-of-waves-for-kids/
https://www.dkfindout.com/us/science/sound/

Link to student half-sheet reading on pitch: What is pitch?

Using the wave representation:



The wave representation can show pitch and volume of a sound by showing the height of the wave (amplitude/volume) and the width between crests (wavelength relating to pitch). *Image source: https://vhmsscience.weebly.com/waves.html*

Part 2: Modeling properties of sound

Turn-and-Talk

1. Framing: Orienting students to today's concept(s).

a. Have students look at representations of sound chart from L1 containing the different ways students represented sound. Have students look closely across these representations. *What do you notice?* Turn-and-talk.
b. Introduce today's question: *What are different ways to represent properties of sound, such as amplitude, using the drawn symbol we already have?*

Mini-Lesson

2. Just-in-Time Instruction: Developing Models - Attributes of Symbols

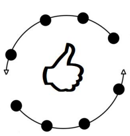
Today students will learn more about how to manipulate the attributes of a symbol to communicate more information in a model. Revisit the diagrams from the half-sheet reading on amplitude and pitch. Review the meaning of amplitude. Then display the diagrams and ask:

- *What did the illustrators do to show show amplitude? pitch?*
- *Do these ways of showing sound match any we have on our chart?*

Model to Explain

3. Explore: Model-to-Explain: Tuning Fork - How can we hear it?

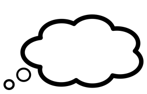
a. Tell students that they will now have time to develop a model showing how the tuning fork works in the air, (*How does a tuning fork make sound? How can we hear it?)* and comparing it to how it works with the water.
b. Remind students of the criteria of taking a way of representing sound and changing it up to show how a property of the sound, such as amplitude, changes. Students can also incorporate their learning from human systems, sound over a distance, force-and-volume, and recent learning about amplitude as a way to process the past few lessons together.
c. As students work, circulate to support student engagement in the task.



Gallery Walk

4. Summarize: Gallery walk, then summarize learning.

a. Tell students to leave their models on their desks and have students do a silent 3 minute gallery walk noticing what other students did to their sound symbol to show something about what the sound from the tuning fork is doing. Have students turn-and-talk about what they noticed. *(Time permitting: This discussion of models could be longer with students projecting, comparing, and asking each other about their ways of representing sound properties. If shorter, just have a few students share some noticings and move to summarizing.)*

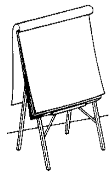


Think Time

b. Give think time and a few minutes of discussion going one column at a time, spending the most time on learning and connections.

Share & Discuss

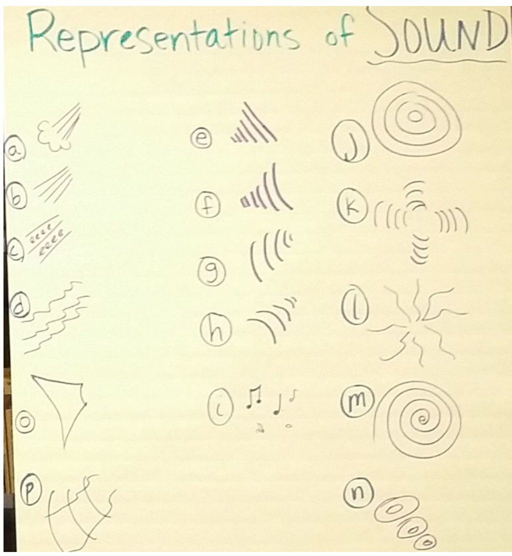
Investigation	Observations	Learning	Connections
What did we do? What were we figuring out?	What did we observe? What patterns did we notice between force and waves?	How can we explain patterns in the data? What questions do we still have about sound waves?	What does this have to do with explaining why the singer was able to shatter the glass?

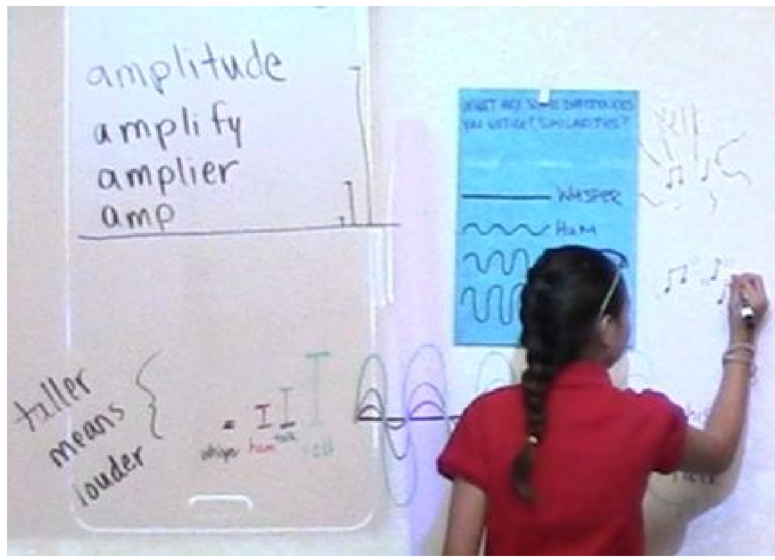


Summary Table

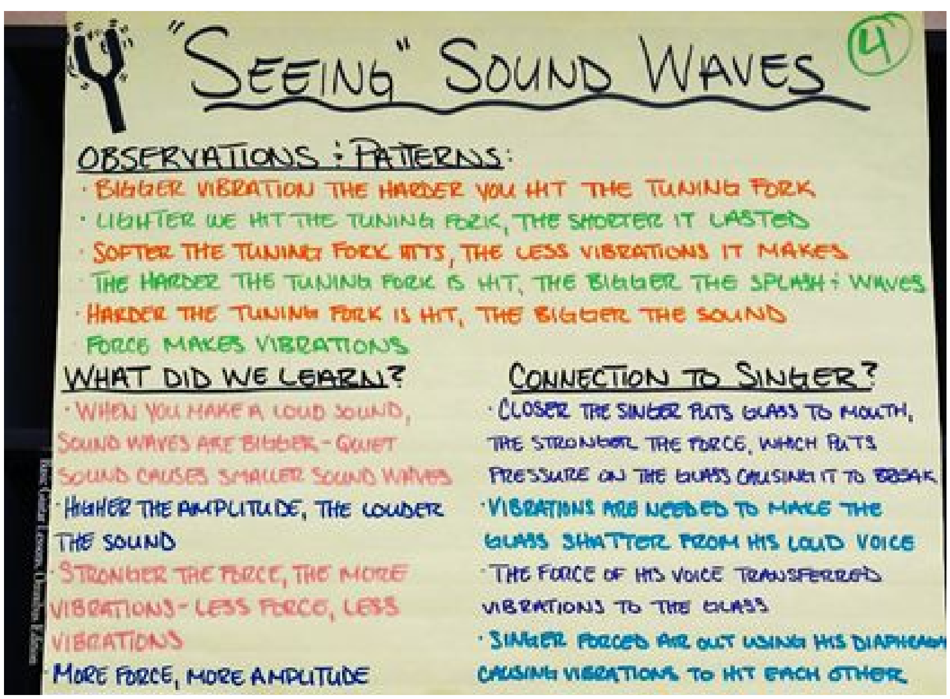
c. Decide on: What information should we put on our summary chart to remember for later? What do we think is important about what we did? observed? and learned today? How does knowing about force and waves help us explain how the singer could shatter the glass?

Photos from Lesson 4





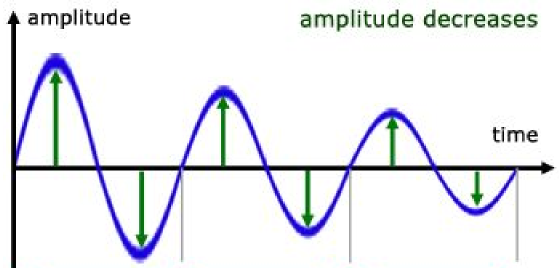
Students learned that using a wave representation the height indicates the amplitude which we hear as volume. The teacher returned to the Human Systems activity comparing whisper, hum, talk, and yell to introduce the idea of amplitude. The taller the wave, the louder the sound. Then, the teacher had students choose a representation from the chart and think about how to represent amplitude. This student chose the music note representation off the class chart and showed volume by adding squiggles around the music notes. The longer the squiggle, the louder the sound.



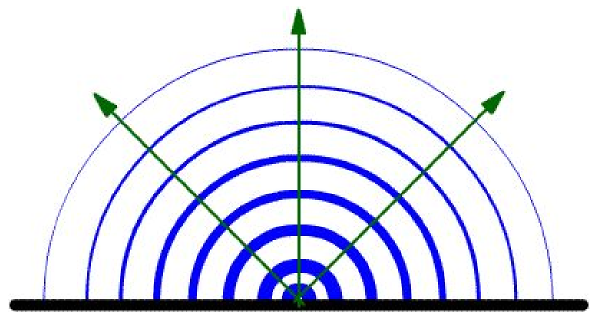
Summary chart using student input. Responses will vary by class and should come from class discussions and can be added to or changed.

What is amplitude?

Strum one guitar string or hit a piano key one time and listen as the sound fades away. You will hear the volume sounds louder at first and gets less and less over time. What's happening? Amplitude is a description of the sound wave's strength. Amplitude is often drawn as the height of the sound wave. Amplitude, or wave height, decreases over time if no more energy or force is put back into the system. As the amplitude of a sound wave decreases, the volume of the sound decreases. One way computers represent sound waves is shown below. Over time, the amplitude, or wave height, decreases if no more energy is put into the system. This results in less and less volume over time.



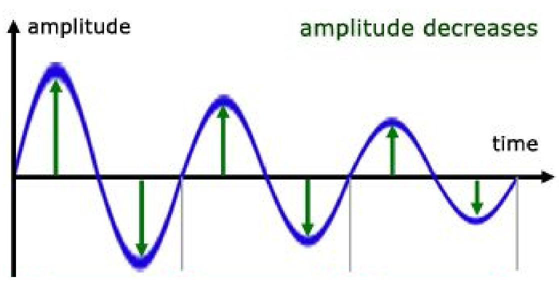
In this model, amplitude is shown as the height of the sound wave. A louder sound has more amplitude so it has a taller or higher wave. This wave shows a sound that is fading over time as the sound energy spreads out into a room.



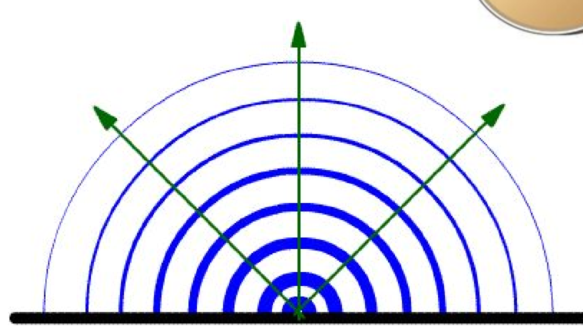
In this model, the illustrator is showing amplitude with the thickness of the line. The source of the sound is the origin and as the sound wave moves away in all directions, the sound intensity decreases which is shown by thinner and thinner lines.

What is amplitude?

Strum one guitar string or hit a piano key one time and listen as the sound fades away. You will hear the volume sounds louder at first and gets less and less over time. What's happening? Amplitude is a description of the sound wave's strength. Amplitude is often drawn as the height of the sound wave. Amplitude, or wave height, decreases over time if no more energy or force is put back into the system. As the amplitude of a sound wave decreases, the volume of the sound decreases. One way computers represent sound waves is shown below. Over time, the amplitude, or wave height, decreases if no more energy is put into the system. This results in less and less volume over time.

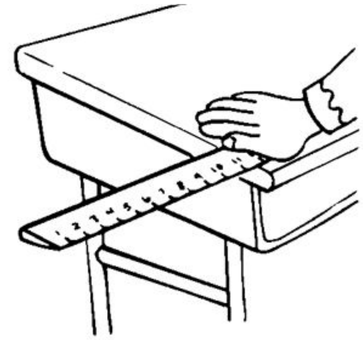


In this model, amplitude is shown as the height of the sound wave. A louder sound has more amplitude so it has a taller or higher wave. This wave shows a sound that is fading over time as the sound energy spreads out into a room.



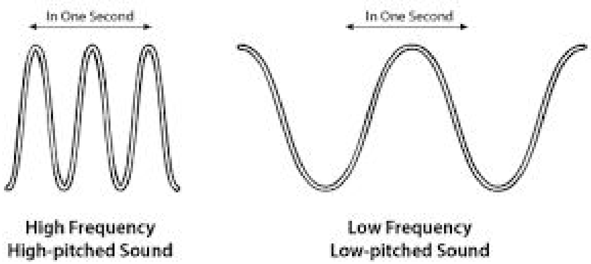
In this model, the illustrator is showing amplitude with the thickness of the line. The source of the sound is the origin and as the sound wave moves away in all directions, the sound intensity decreases which is shown by thinner and thinner lines.

What is pitch?

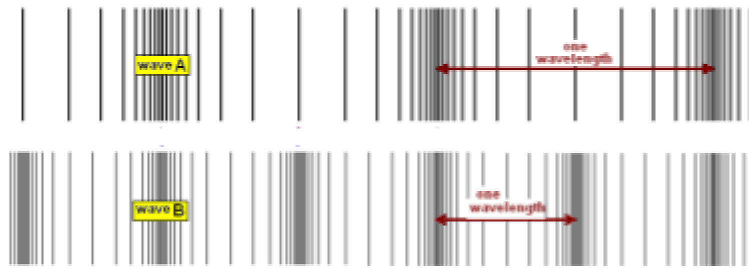


Pitch is a quality of sound that refers to how high or low the sound is. A sports whistle or bird song has a higher pitch than a bass drum. We already know that to make sound there must be a vibration. The speed of vibration relates to the pitch of the sound. The faster the vibration, the higher the pitch. And, conversely, the slower the vibration, the lower the pitch.

Try this: Extend a plastic ruler over the edge of a table so that 8 inches of the ruler extends off the table into the air. Give it a push down with your finger. What do you notice? Now pull back the ruler so only 4 inches extend off the table. Give it a push down with your finger with the same pressure or force you used before. How is the sound different? What do you notice about the vibrations?



In this model, the high pitched sound has two wavelengths in one second whereas the low pitched sound only one wavelength in one second.. Using a wave representation, pitch is shown by the horizontal (side-to-side) size.. High pitched sounds have shorter wavelengths than lower pitched sounds.
Image source: Open School BC

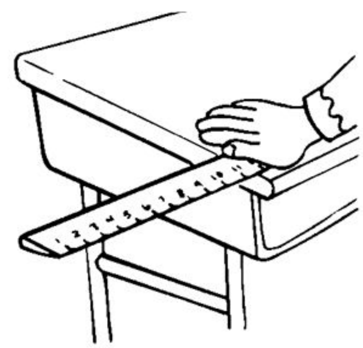


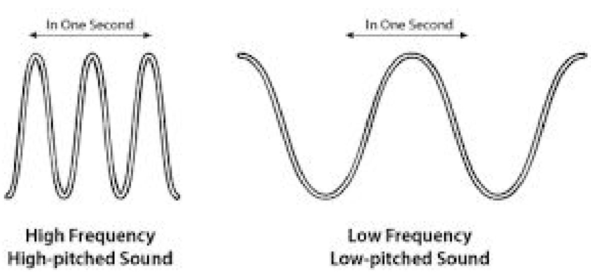
In this model, the illustrator shows pitch with the distance between lines. Wave A (top) has a longer wavelength and a lower pitch sound than Wave B which has a shorter wavelength and higher pitch sound. Image source: http://www.docbrown.info/ephysics/wavesound.htm .

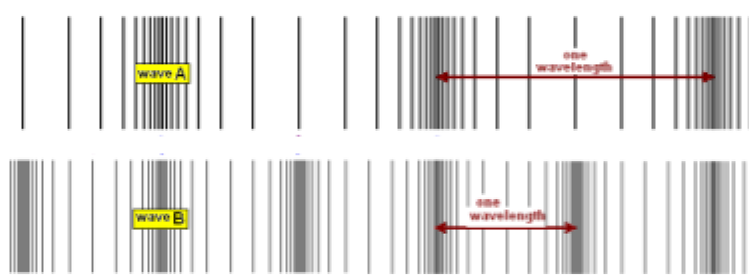
What is pitch?

Pitch is a quality of sound that refers to how high or low the sound is. A sports whistle or bird song has a higher pitch than a bass drum. We already know that to make sound there must be a vibration. The speed of vibration relates to the pitch of the sound. The faster the vibration, the higher the pitch. And, conversely, the slower the vibration, the lower the pitch.

Try this: Extend a plastic ruler over the edge of a table so that 8 inches of the ruler extends off the table into the air. Give it a push down with your finger. What do you notice? Now pull back the ruler so only 4 inches extend off the table. Give it a push down with your finger with the same pressure or force you used before. How is the sound different? What do you notice about the vibrations?







In this model, the high pitched sound has two wavelengths in one second whereas the low pitched sound only one wavelength in one second.. Using a wave representation, pitch is shown by the horizontal (side-to-side) size.. High pitched sounds have shorter wavelengths than lower pitched sounds.
Image source: Open School BC

In this model, the illustrator shows pitch with the distance between lines. Wave A (top) has a longer wavelength and a lower pitch sound than Wave B which has a shorter wavelength and higher pitch sound. *Image source:* http://www.docbrown.info/ephysics/wavesound.htm .

Student Reading, Lesson 4: Seeing Sound Waves

Lesson 5 Knock, knock! Energy Moves through Matter

Purpose

This lesson focuses students on how sound energy transfers through matter. Sound energy is transferred through mediums differently based on the arrangement of the particles.

In this lesson, students will:
- Describe and discuss patterns in the knocking sounds they observed.
- Understand that matter is made up of particles too small to see.
- Draw conclusions about the relationship between sound energy traveling in gas versus solids.

This lesson provides some new information to students through non-fiction text, paired with a physical experience to help students make sense of sound as energy. For more about supporting ongoing changes in student thinking, see http://AmbitiousScienceTeaching.org

Learning Target

Focus Questions
How does sound energy travel?

Learning Target
I can make observations about force and volume to develop models of sound energy transfer. **You do not need to post a target statement. Instead, pose a question on the board.*

NGSS 3-D
SEP: Develop and use models *Develop a model to describe phenomena*
PS1.A: Structure and Properties of Matter *Matter of any type can be subdivided into particles too small to see*
PS3.A: Definitions of Energy *Energy can be moved from place to place by moving objects or sound*
CCC Patterns *Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena.*

Materials

For the class:
- Summary chart, sticky notes, markers
- Representations of sound chart (L1)
- Video Clip: Bill Nye (2:32)

Per student:
- Half-page reading: Matter (link)
- Half-page recording sheet, two sided (link)
- Science Notebook

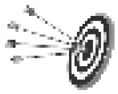
Lesson Step Summary

Part 1: Making Observations (35 mins)
1. **Frame:** Connect to an idea about sound traveling or moving
2. **Mini-Lesson:** Read about matter and molecules. What does this have to do with understanding sound energy?
3. **Explore**: Make observations about knocking.
4. **Summarize:** Quick write about observations connecting to the reading.

Part 2: Explaining Observations and Summarizing Learning (45 mins)
1. **Frame**: Review observations from part 1.
2. **Mini-Lesson**: Examining published model of sound energy in a video showing energy moving through matter.
3. **Explore**: Modeling to explain observations of how knocking sound travels
4. **Summarize**: What did we do? What did we learn? Connect to the singer.

Part 1: Learning about Matter

1. Framing: Orienting students to today's concept(s).



Purpose

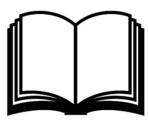
Turn-and-Talk

a) Open with a statement connecting to a student's idea or something students have been saying related to sound moving—that sound goes through the air, is in the air, or moves through the wall or door, or how the singers voice got to the glass—to orient students to the idea that sound energy travels.

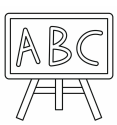
b) Tell students to think about this question then turn-and-talk: **How do you think the sound from my voice is going to all of you right now so you can hear me?**

It might sound like this: *One thing I've noticed during our science talks is that we keep saying things like, sound is in the air or sound goes through the air. So I was wondering, how exactly does sound energy travel? Today we will be making observations about sound going through different materials. But first, let's do some thinking. How do you think the sound from my voice is going to all of you right now so you can hear me? Think for a moment...Okay, turn and talk.* [Listen in on student ideas.] *Before we do some sound explorations, let's do some reading about matter, like air, and what it's made of. You might remember that matter is the stuff around us, like solids, liquids, and gases. This information might help us think more about how sound travels.* [Transition to reading task]

2. Just-in-Time Instruction: What is matter? What is it made of?



Read for information

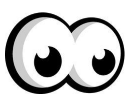


New Terms

Read the short half sheet reading about matter. After reading, come together to review the new terms (matter, molecule). Spend a few minutes looking at text features and digesting the meaning of the terms.

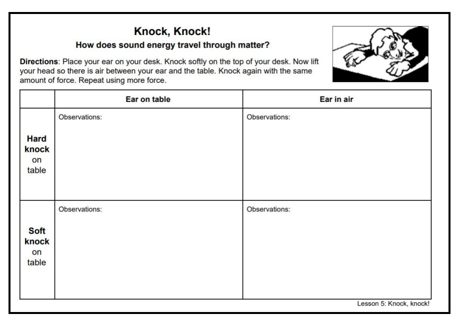
- *What is matter? What are molecules?*
- *How are the molecules arranged in solids? liquids? gases?*
- *What do you think happens to water molecules when we heat liquid water?*
- *This reading did not say anything about sound energy. So why or how could this information could be useful to us?* (If students aren't sure yet, have them keep this question and information in mind during the subsequent knocking task.)

3. Explore: Make Observations about Knocking



Observations

Tell students they will knock on their desks with their ear on the desk. Repeat, lifting your ear in the air. Record observations in science notebooks or use this data table.



Knock, Knock!

How does sound energy travel through matter?

Directions: Place your ear on your desk. Knock softly on the top of your desk. Now lift your head so there is air between your ear and the table. Knock again with the same amount of force. Repeat using more force.

	Ear on table	Ear in air
Hard knock on table	Observations:	Observations:
Soft knock on table	Observations:	Observations:

Lesson 5: Knock, knock!

Back-Pocket Questions

Back-Pocket Questions:

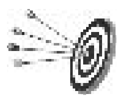
- What do you hear when you...?
- How is what you hear different between listening through the table or through the air?
- How do you think the knocking sound travels through the table? through the air?

4. Summarize: Quick write about observations.

Have students do a silent quick write about what they did today, what they observed, and using information from the reading on matter to explain how they think sound energy travels through the table and air.

Quick Write

Part 2: Modeling-to-Explain how Sound Energy Travels



Purpose

1. Framing: Orienting students to today's concept(s).

Have students re-read what they wrote during the quick write at the end of Part 1. Turn-and-talk with a partner about what they did and what they are currently thinking about how sound energy travels through matter. Then tell students today's focus will be more on modeling to explain what they think is going on that helps sound energy travel through matter.

Video

Turn-and-Talk

2. Just-in-Time Instruction: Example Model Critique

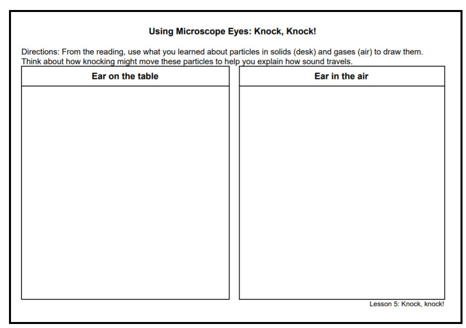
Watch this video clip featuring a physical model that communicates one explanation about how sound energy travels through air. Use turn-and-talks and whole-class discussion about these questions:

- What does this model show about sound energy?
- What do the pucks represent? What does the push represent?
- If we were to draw this model, what are some different ways we can show movement or collisions?

3. Explore: Model-to-Explain: How does the knocking sound travel?

Model to Explain

Tell students that they will have time to develop a model showing how the sound energy from the knock travels through matter. Challenge students to figure out ways to represent the molecules in the matter and how the energy travels. *How is the sound traveling in the table to the ear similar or different than going into the air and then ear?*



Using Microscope Eyes: Knock, Knock!

Directions: From the reading, use what you learned about particles in solids (desk) and gases (air) to draw them. Think about how knocking might move these particles to help you explain how sound travels.

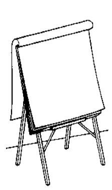
Ear on the table	Ear in the air

Lesson 5: Knock, knock!

Share & Discuss

Have students turn-and-talk or share with their table group as to how they used symbols to show energy moving and molecules to explain how the knock sound travels. This could also be done whole-group.

4. Summarize: Discuss and summarize learning



Summary Table

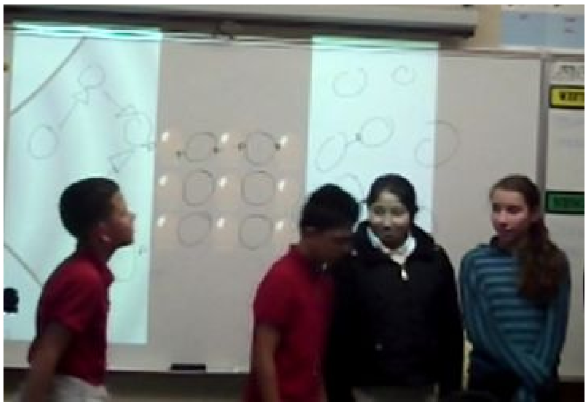
Give think time and a few minutes of discussion going one column at a time, spending the most time on learning and connections.

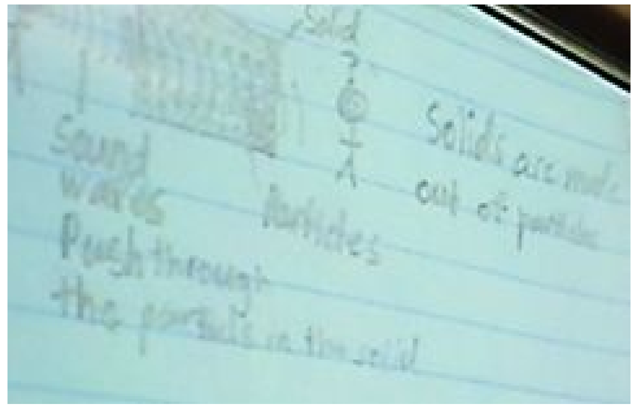
Decide on: What do we think is important about what we did? observed? and learned today? How does knowing about force and waves help us explain how the singer could shatter the glass?

Investigation	Observations	Learning	Connections

What did we do? What were we figuring out?	What did we observe? What patterns did we notice between force and waves?	How can we explain patterns in the data? What questions do we have about energy? matter?	What does this have to do with explaining why the singer was able to shatter the glass?

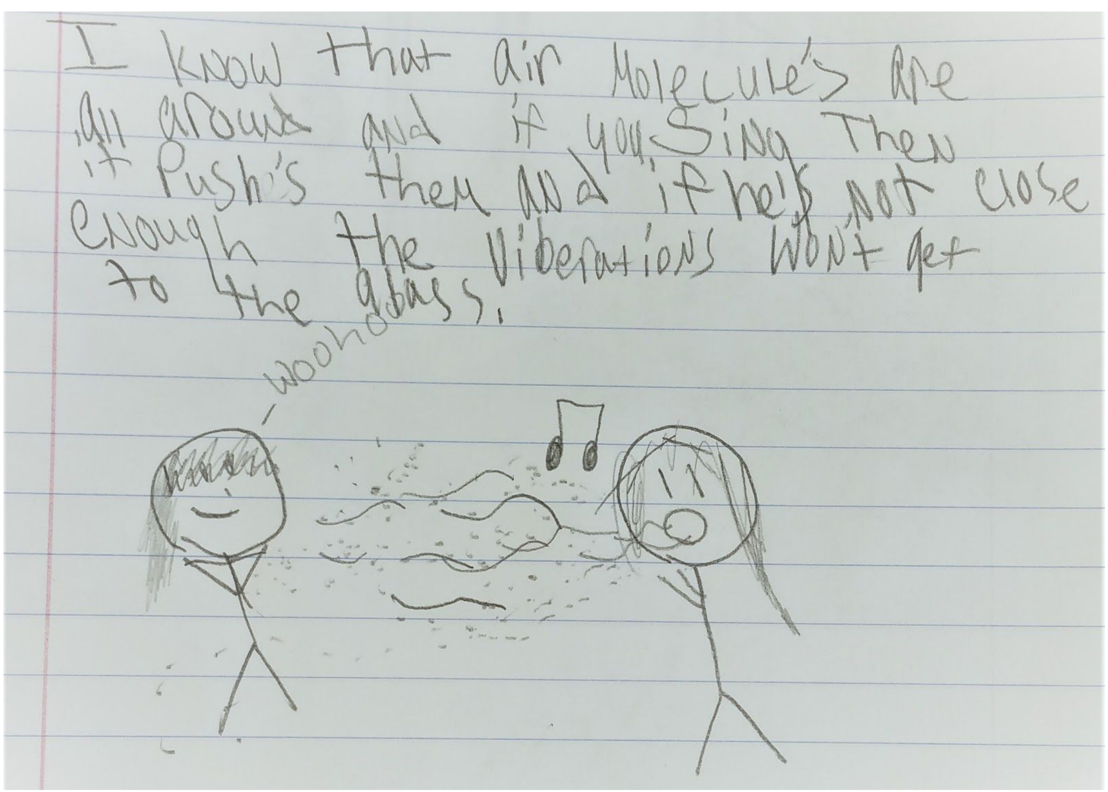
Photos from Lesson 5, Part 2





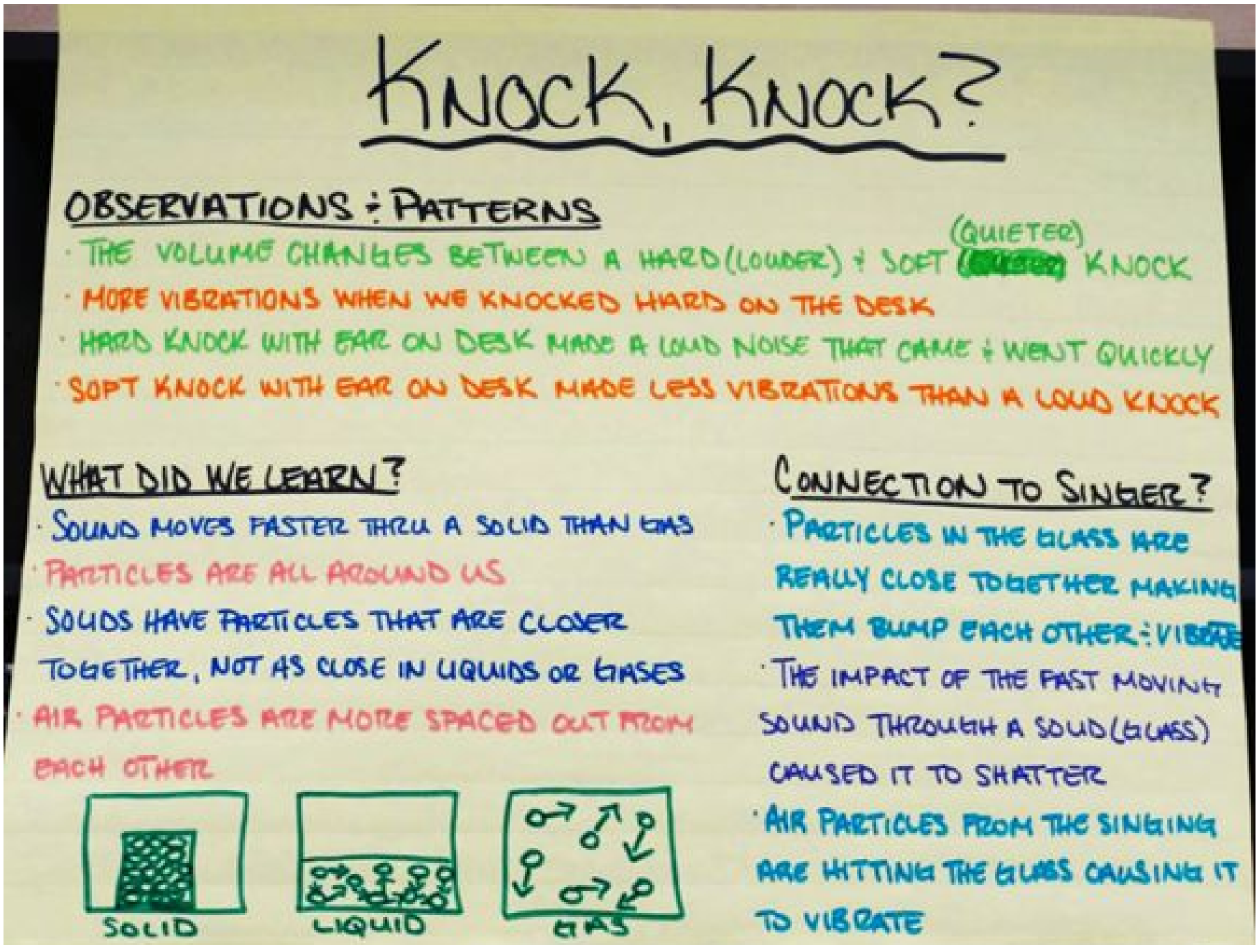
Left: Students repeated the demo from Lesson 4 of standing shoulder-to-shoulder to feel the wave energy bump through them pushing out the student on the left but other students did not move much. This kinesthetic model shows how energy moves much faster through matter than the actual movement or displacement of the molecules in matter.

Right: Photo from student notebook model explaining how sound travels through solids, like their desk. This student labeled “solid” and “particles” and wrote: “Sound waves push through the particles in the solid.” and “Solids are made out of particles.” This student used a crescent representation to show sound and circles to show particles.



Example quick write from student notebook: *"I know that air molecule's are all around and if you sing then it push's them and it he's not close enough the viberations won't get to the glass."*

This student is merging ideas about how sound energy travels through air using molecules and using this idea to explain an observation from the phenomenon, why the singer has to be close to the glass. the student did not draw molecules all around, only between the people, yet wrote that molecules are all around. A next step for this student would be to figure out how to show air molecules pushing each other in the model.

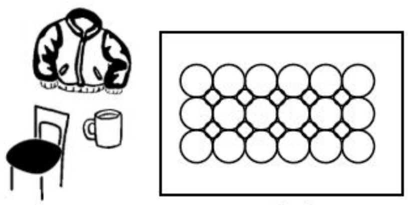


Summary chart example from this lesson. The teacher summarized bullets from the whole-class discussion. Alternatively, the teacher could have student(s) be the scribe(s) to write on the chart.

The "Stuff" in our World: What is matter?

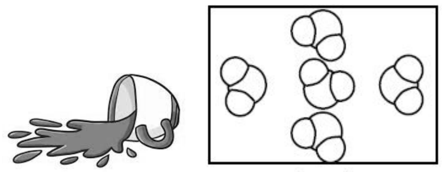
Things in our world take up space and have some weight. We most commonly encounter three forms the stuff, or matter, on Earth: solids, liquids, and gases. A jacket, chair, and cup are all examples of solids. You can't put your hand through a solid. If you had microscope eyes, you would see tiny molecules in solids are packed together tightly. Water, juice, and oil are all examples of liquids. We can move our hands through liquids, like swimming in a pool. Tiny molecules in liquids are not packed as tightly as solids so we can move in between them. Two examples of gases are the air that we breathe and helium in birthday balloons. We can also move through gases. Molecules in gases are not close together. Consider H_2O (water), for example, each molecule is the same; however, depending on how fast they move or how close together they are, we might see the water as a solid ice cube, a liquid puddle, or water vapor going into the air.

Solid



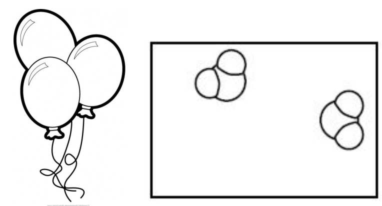
When molecules have less and less energy and slow down enough, they get closer together. Eventually, the molecules connect together to form a solid material.

Liquid



Molecules that have some energy but not too much or not too little can move around each other. We see liquid. Liquids can pour and flow and take the shape of the container.

Gas

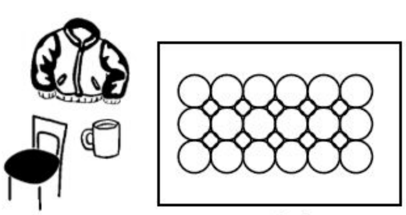


When liquid water gets enough energy like from the hot sun or stove, liquid water can change and move into the air as a gas. Molecules move farther apart and zoom around very quickly.

The "Stuff" in our World: What is matter?

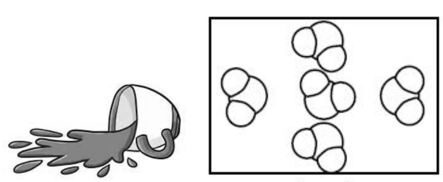
Things in our world take up space and have some weight. We most commonly encounter three forms the stuff, or matter, on Earth: solids, liquids, and gases. A jacket, chair, and cup are all examples of solids. You can't put your hand through a solid. If you had microscope eyes, you would see tiny molecules in solids are packed together tightly. Water, juice, and oil are all examples of liquids. We can move our hands through liquids, like swimming in a pool. Tiny molecules in liquids are not packed as tightly as solids so we can move in between them. Two examples of gases are the air that we breathe and helium in birthday balloons. We can also move through gases. Molecules in gases are not close together. Consider H_2O (water), for example, each molecule is the same; however, depending on how fast they move or how close together they are, we might see the water as a solid ice cube, a liquid puddle, or water vapor going into the air.

Solid



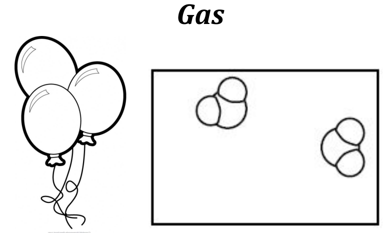
When molecules have less and less energy and slow down enough, they get closer together. Eventually, the molecules connect together to form a solid material.

Liquid



Molecules that have some energy but not too much or not too little can move around each other. We see liquid. Liquids can pour and flow and take the shape of the container.

Gas



When a liquid gets enough energy, like from the hot sun or stove, liquids can change and move into the air as a gas. Molecules move farther apart and zoom around very quickly.

Student Reading, Lesson 5: Knock, Knock

Knock, Knock!

How does sound energy travel through matter?

Directions: Place your ear on your desk. Knock softly on the top of your desk. Now lift your head so there is air between your ear and the table. Knock again with the same amount of force. Repeat using more force.

	Ear on table	**Ear in air**
Hard knock on table	Observations:	Observations:
Soft knock on table	Observations:	Observations:

Lesson 5: Knock, knock!

Knock, Knock!

How does sound energy travel through matter?

Directions: Place your ear on your desk. Knock softly on the top of your desk. Now lift your head so there is air between your ear and the table. Knock again with the same amount of force. Repeat using more force.

	Ear on table	**Ear in air**
Hard knock on table	Observations:	Observations:
Soft knock on table	Observations:	Observations:

Lesson 5: Knock, knock!

Using Microscope Eyes: Knock, Knock!

Directions: From the reading, use what you learned about particles in solids (desk) and gases (air) to draw them. Think about how knocking might move these particles to help you explain how sound travels.

Ear on the table	Ear in the air

Lesson 5: Knock, knock!

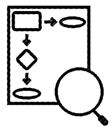
Using Microscope Eyes: Knock, Knock!

Directions: From the reading, use what you learned about particles in solids (desk) and gases (air) to draw them. Think about how knocking might move these particles to help you explain how sound travels.

Ear on the table	Ear in the air

Lesson 5: Knock, knock!

Lesson 6 Update and Revise Models

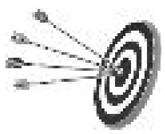


Purpose

This lesson provides an opportunity for students to take stock in what they have done, observed, read/watched, and learned so far over the past several lessons.

- Students review prior experiences and evidence.
- Students will use prior experiences and evidence to justify revising, adding, or removing ideas about the unit phenomenon about how the singer shattered the glass with his voice.

The purpose of this lesson is to help develop ideas to use to revise explanations and models for the phenomena. For more on supporting student sensemaking, http://AmbitiousScienceTeaching.org



Learning Target

Focus question

How has our thinking changed? What do we know now that we didn't know before?

Learning Target

I can use evidence from text, video, and experiments to justify my ideas about why the glass shattered.

**You do not need to post a target statement. Instead, pose a question on the board.*

NGSS 3-D

SEP: Develop and use models
PS1.A: Structure & Prop. of Matter
PS3.A: Definitions of Energy
PS3.B: Conservation of Energy and Energy Transfer
CCC: Cause & Effect
CCC: Systems & System Models

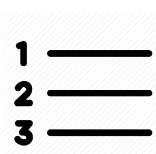
Materials

For the class:

- Summary charts from prior lessons/activities posted on the board, wall, or cabinet doors so students can see them all
- Optional (see decision point): Blank model scaffold, or blank paper one per student (choose a version)
- Stack of students' initial models from lesson 1, one per student
- Chart paper & markers
- 4 colors sticky notes

Teacher decision point

There is no "right way" to support students in updating models. Students could work on a new blank page/template or they could go back to their original initial model with a different color pen and sticky notes. There are pros/cons to either decision so think about what might best support your students in reflecting on their new learning and getting it on paper.

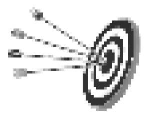


Lesson Step Summary

1. **Launch**: Review what evidence we have collected by doing a gallery walk of summary charts and science notebook "walk". What did we do? What did we learn? What are all the sources of evidence we have now? Generate a checklist of some important ideas to include.
2. **Explore**: On new sheet or with flaps/sticky notes, get started updating models using colors, symbols, arrows, and zoom-ins. Then write ideas in sentences and add evidence for how students know. ***Mid-point check**: Partner listening challenge. Return to models.*
3. **Summarize**: Compare and connect examples of students' updated ideas and their use-of-evidence. What are different ways we showed our new ideas? Different ways to use/show ideas? What questions do we have now? Examine student work to know next steps.

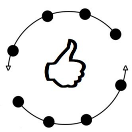
Lesson Steps

1. Frame: Activate and connect to students' prior experiences



Lesson Purpose

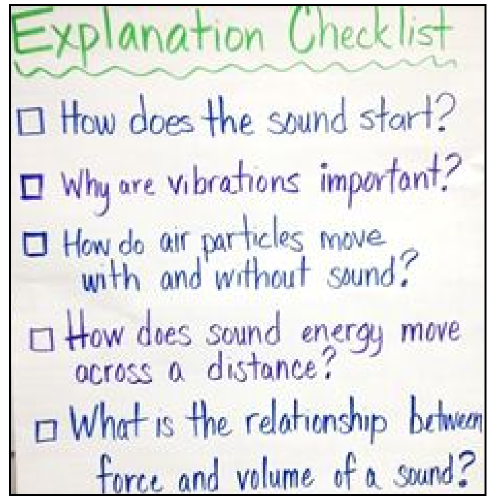
Tell students that today is an opportunity to take stock in everything they have done and learned about so far. Have students do a silent gallery walk of summary charts and their notebooks and be ready to share. Turn and talk to a partner about one thing they did and one thing they learned.



Gallery Walk

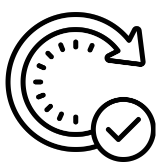
Gather students back to generate a short checklist of phrases of important or "gotta-have" ideas they have been learning and talking about so far. Jot this list on the board or under the document camera so students can refer to it as a guide to help them keep adding more or revising ideas on their model.

Turn-and-Talk



Checklists will vary by class because they are created with students.Use phrases or questions to capture a relationship or process. Vocabulary lists are useful for spelling but not helpful for revising ideas.

2. Explore: Update Models



Update ideas

Let students know your expectations (see decision point next to materials on page 1 of lesson) whether they are starting a new model or using colored pens/sticky notes to update their initial models. If using sticky notes, use a different color for add, change, remove, and questions.

Students work on their models. Circulate as students work to notice how they are using what they have learned in their models. As needed, do a whisper conference to support student engagement in the task.

If a student…

… *seems stuck getting started*:

Ask students to choose an idea from the checklist to start with and to tell you a little bit about it (oral rehearsal) and then ask: *How could you show that in pictures and words on your model?* Continue circulating.

… *talks to you about their idea but isn't putting it on paper.*

Ask the student if they think drawing the idea or writing it it words makes more sense to them and suggest they start there. If the student often does not write a lot, sticky notes can also help so that students aren't feeling like they need to fill a page but just enough to fill a sticky note for *that* idea. Suggest a sticky note for each idea on the checklist to help get their ideas flowing.

3. Mid-point Check-in: Partner listening challenge.

Clarifying Ideas

Have students pause and put a finger on one idea they would feel comfortable explaining to a partner.

Give a “listening challenge” and say that listeners ask questions to get the scientist to clarify ideas. Jot a few prompts for “What can I say?” in response to the speaker.

Have students share ideas with 1-2 partners then return to working on updating and revising their models.

Pair up with another student. Decide who will be a speaker and listener first. The speaker shares about one idea. Then, listeners…

What can I say?
- *“Tell me more about…”*
- *“What do you mean by…?”*
- *“Why did you___?”*
- *“Can you explain___ in more detail?”*
- *“How did you___?”*
- *“Why did you show/explain ___ that way?”*

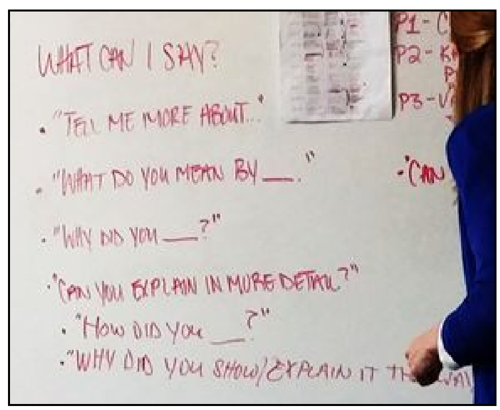
4. Summarize: Compare & Connect

Compare & Connect

Bring the class together and ask for volunteers who can show an example of how they addressed one item on the explanation checklist. Take turns and add on. Students may have more than one way to show the same idea. You can also ask students, “How do you know?” or “What did we do in class that helped you with that idea?”

Exit task sticky note: Quick jot about how did your thinking about _(choose an idea on the checklist)_ change? What made it change?

Photos from Lesson 6

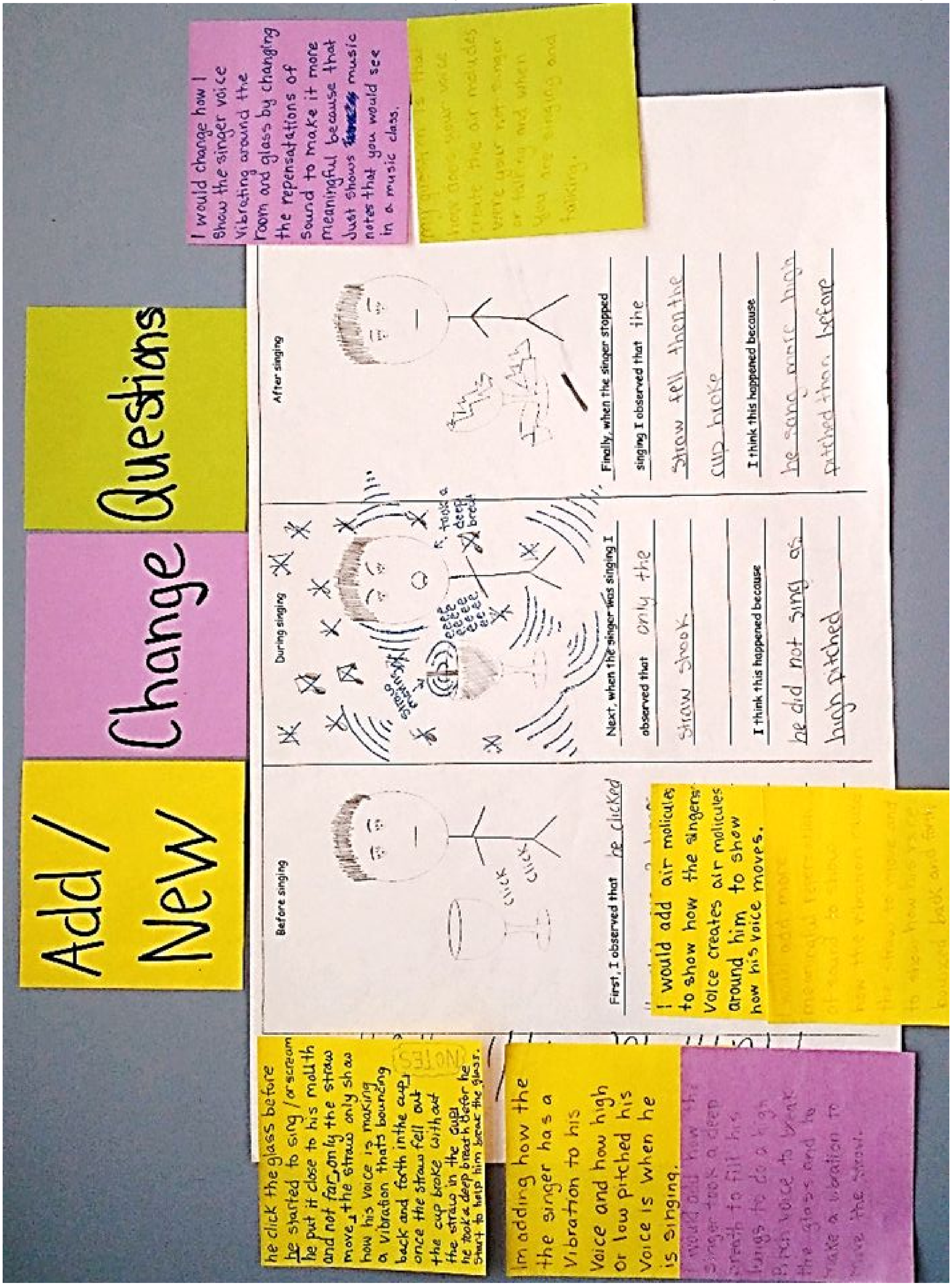


LEFT: his is a photo of how this teacher hung the summary charts in her room so students could easily refer to them to update and revise their models with evidence from investigations.

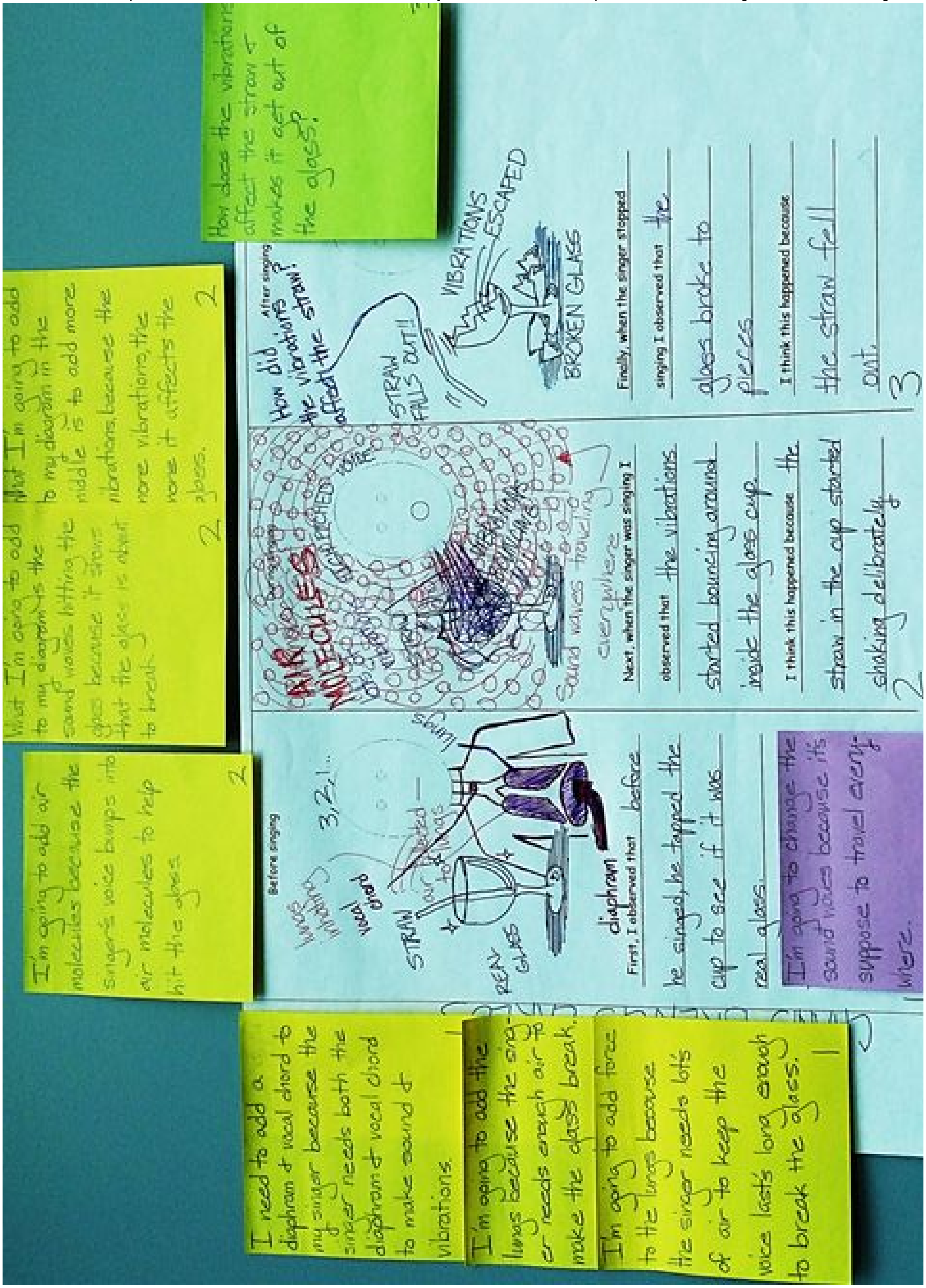
RIGHT: As a mid-point check-in, the teacher had students pair up and do a “good listener” challenge by responding to ideas from the person (speaker) sharing their model first. The speaker picks one idea to share -- something they added, removed, or changed-- then the listener responds with a prompt. Then the speaker and listener switch roles. This exchange often gives students something to clarify or add.

What can I say?
- “Tell me more about…”
- “What do you mean by…?”
- “Why did you___?”
- “Can you explain___ in more detail?”
- “How did you___?”
- “Why did you show/explain ___ that way?”

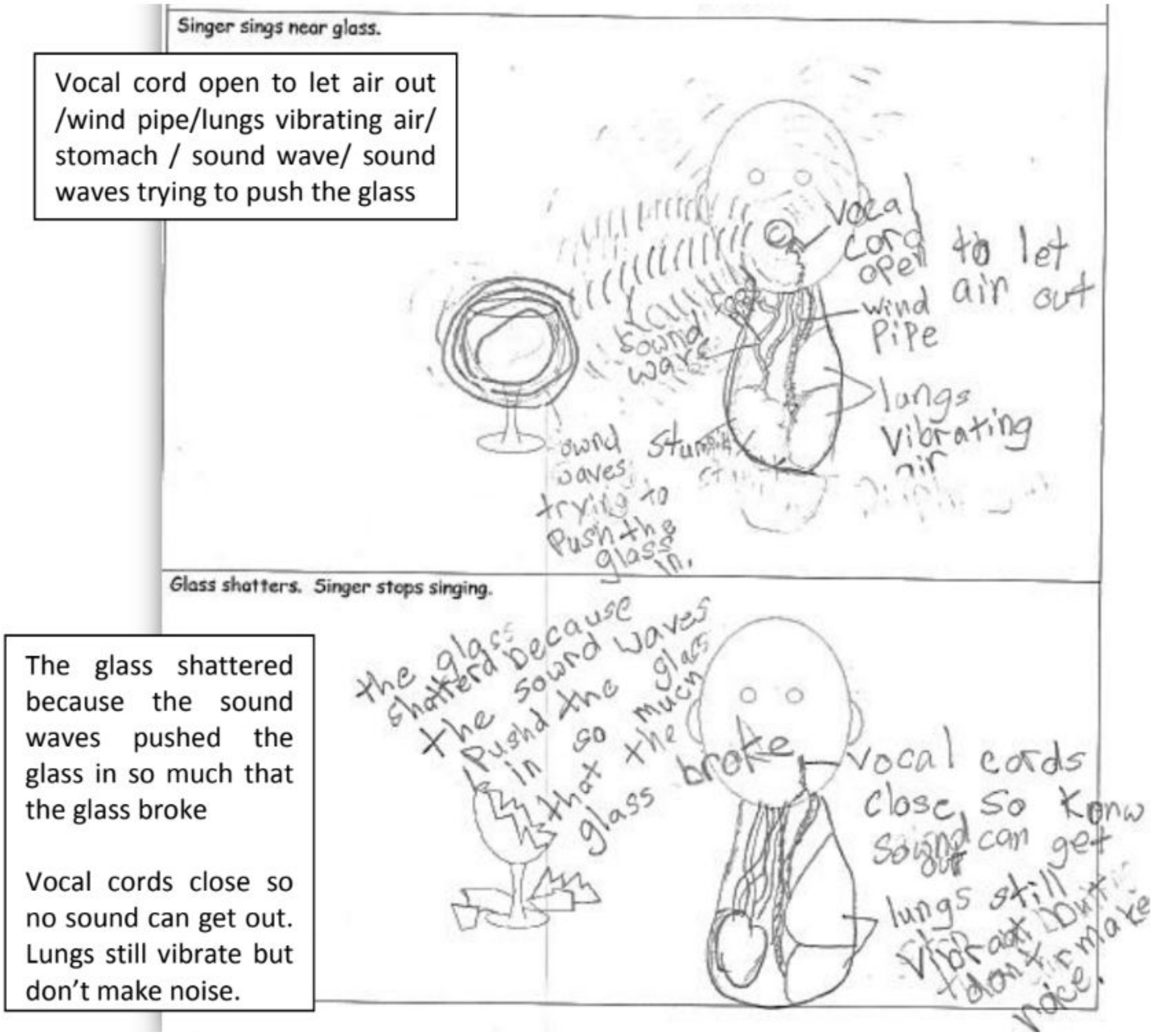
In these model updates, students used color-coded sticky notes and colored pens to show changes in their thinking.



In these model updates, students used color-coded sticky notes and colored pens to show changes in their thinking.



This student started from a blank model scaffold template and put together ideas from prior lessons then compared this updated model with his original model.



Analyzing Student Work

Look for evidence of understanding of the following key science ideas from recent lessons as you examine students' updated models.

- How many students attended to these ideas?
    - Energy can be transferred from one place to another. Waves transfer energy.
    - How or where the sound energy changes over a distance
    - Vibrating matter creates a sound wave that moves energy and makes sound.
    - Recognizes that energy is present and moving in waves when there is sound.
    - Include properties of the sound wave (amplitude, pitch, wavelength, etc) to explain how or why this particular sound can break the glass.
    - How sound transfers through matter, like air or glass
- If so, to what degree did they demonstrate their understanding? Did they just label or mention a concept or did they use the concept to explain a mechanism or cause-and-effect process?
- If not, was there scaffolding or resources that would have pointed them to include them or do you think students do not find them useful or applicable to the singer phenomenon?

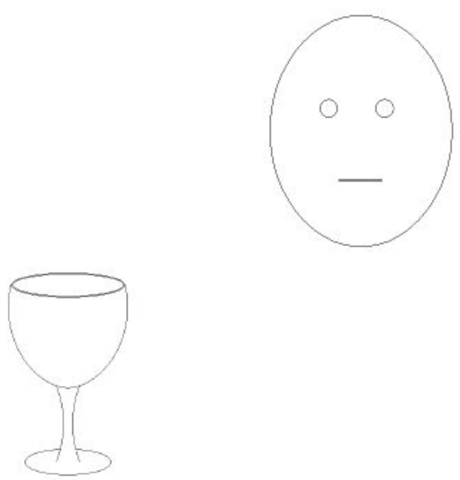
Name: ______________________________

Date: __________ Teacher: _______________

How did the singer shatter the glass with his voice?

Updating our Ideas

Before



The singer flicks the glass because ____________________

____

____

____

My evidence for my idea is ________________________

____

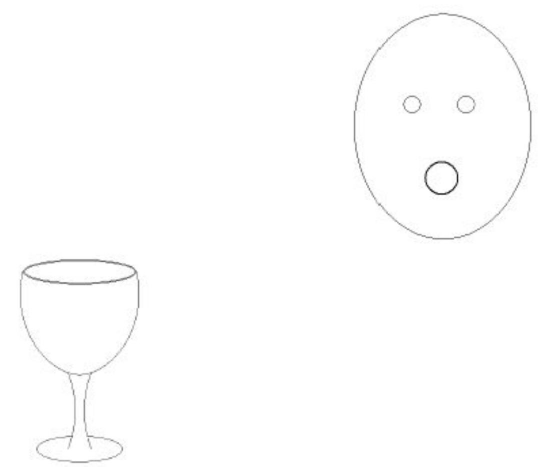
____

____

Did you….?

- ❑ Draw sound using a symbol or representation
- ❑ Show how or where sound travels
- ❑ Show properties of sound like volume or pitch

During



The singer has to sing loudly because __________________

____

My evidence for my idea is ________________________

____

____

The singer has to be close to the glass because ____________

____

I know this because ____________________________

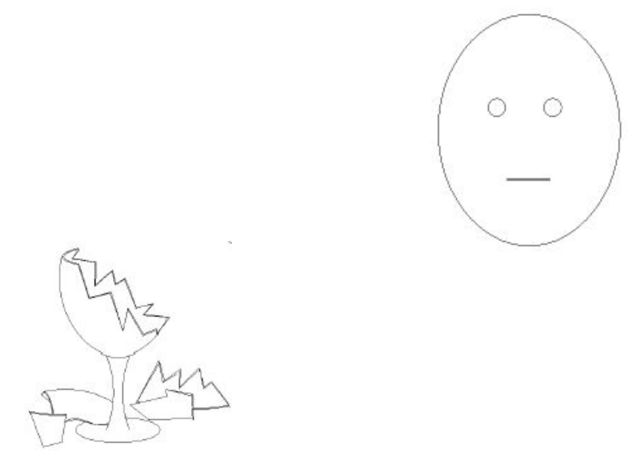
____

____

Did you….?

- ❑ Draw sound using a symbol or representation
- ❑ Show how or where sound travels
- ❑ Show properties of sound like volume or pitch

After



I think the glass eventually broke because ______________

____

____

____

We could no longer detect the sound from the singer or the glass because ________________________________

____

____

____

Did you….?

- ❑ Draw sound using a symbol or representation
- ❑ Show where sound travels when we can no longer hear it
- ❑ Show properties of sound like volume or pitch

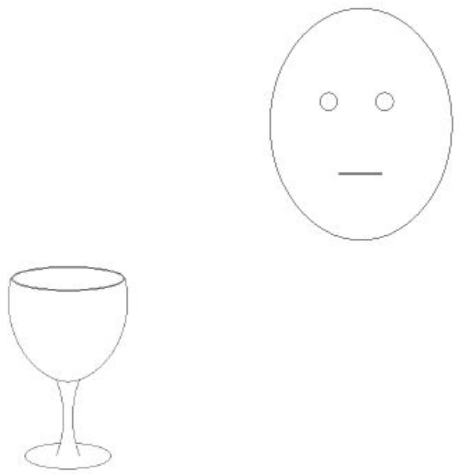
Name: ______________________________

Date: __________ Teacher: ______________

How did the singer shatter the glass with his voice?

Updating our Ideas

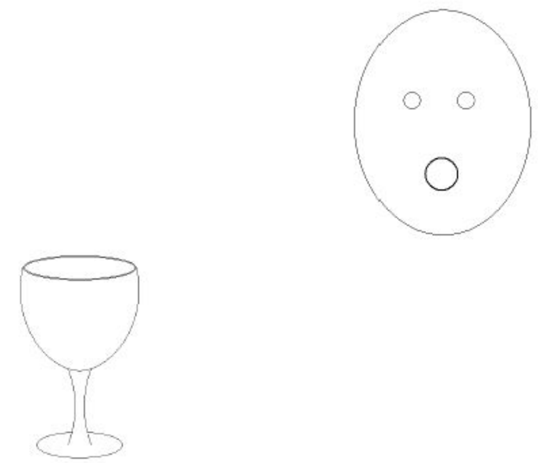
Before



Did you….?

- ❏ Draw sound using a symbol or representation
- ❏ Show how or where sound travels
- ❏ Show properties of sound like volume or pitch

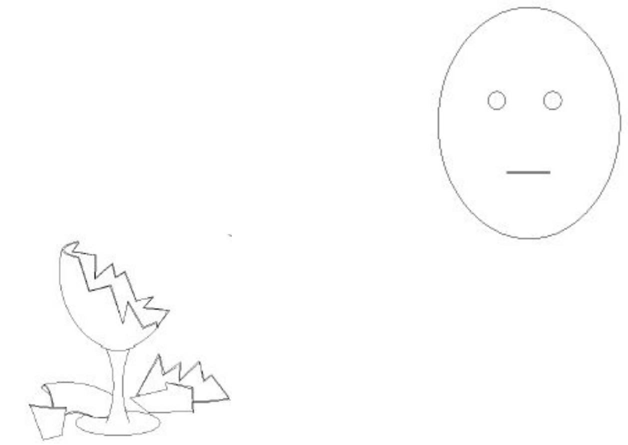
During



Did you….?

- ❏ Draw sound using a symbol or representation
- ❏ Show how or where sound travels
- ❏ Show properties of sound like volume or pitch

After



Did you….?

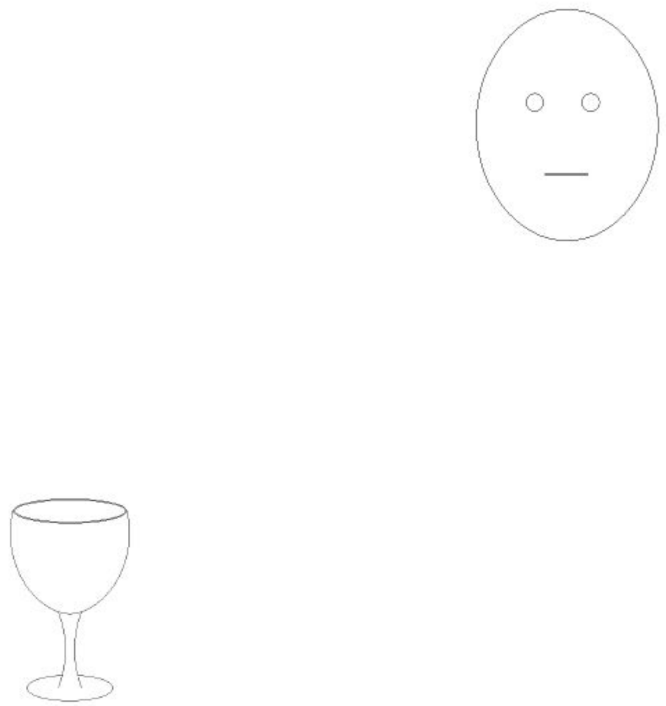
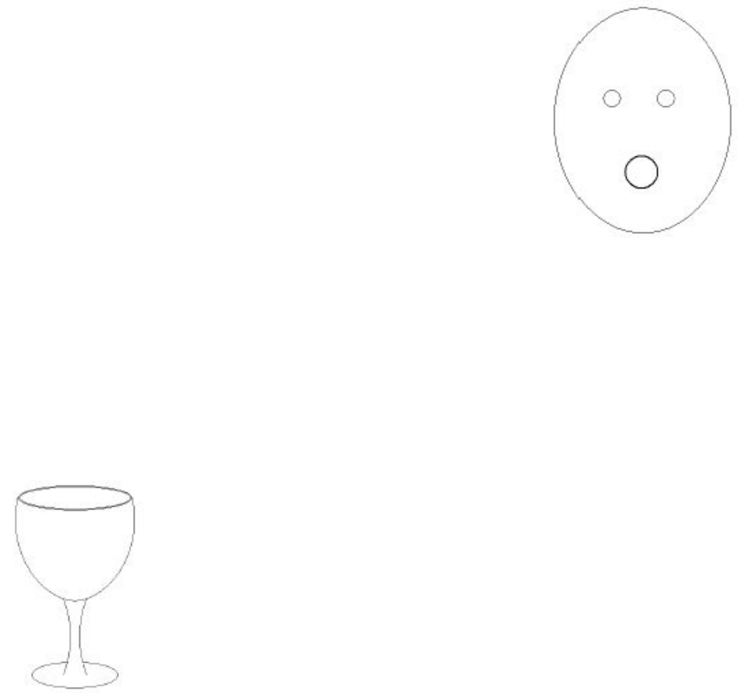
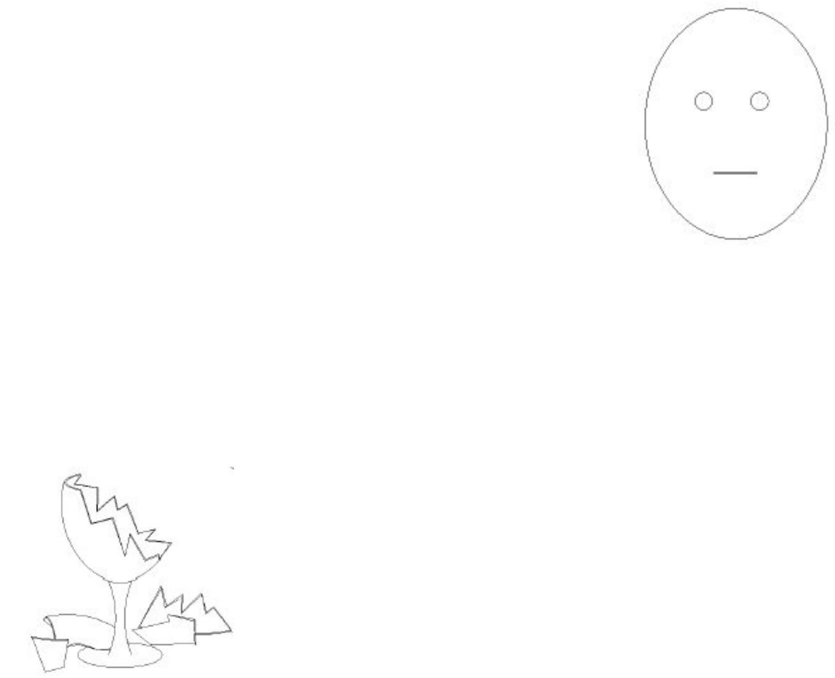
- ❏ Draw sound using a symbol or representation
- ❏ Show where sound travels when we can no longer hear it
- ❏ Show properties of sound like volume or pitch

Name: ______________________________

Date: __________ Teacher: _______________

How did the singer shatter the glass with his voice?

Updating our Ideas

Before	During	After
		

Sound Energy Unit Explanation Checklist

Did you show and write about…?

- ❑ How sound travels
  Where does sound come from?
  Where does sound go?
- ❑ How or why distance matters
  What happens to sound as it goes farther from the source?
  Why does the singer need to be close to the glass?
- ❑ Why volume is important
  Where does he volume of a sound come from?
  Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

- ❑ How sound travels
  Where does sound come from?
  Where does sound go?
- ❑ How or why distance matters
  What happens to sound as it goes farther from the source?
  Why does the singer need to be close to the glass?
- ❑ Why volume is important
  Where does he volume of a sound come from?
  Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

- ❑ How sound travels
  Where does sound come from?
  Where does sound go?
- ❑ How or why distance matters
  What happens to sound as it goes farther from the source?
  Why does the singer need to be close to the glass?
- ❑ Why volume is important
  Where does he volume of a sound come from?
  Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

- ❑ How sound travels
  Where does sound come from?
  Where does sound go?
- ❑ How or why distance matters
  What happens to sound as it goes farther from the source?
  Why does the singer need to be close to the glass?
- ❑ Why volume is important
  Where does he volume of a sound come from?
  Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

- ❑ How sound travels
  Where does sound come from?
  Where does sound go?
- ❑ How or why distance matters
  What happens to sound as it goes farther from the source?
  Why does the singer need to be close to the glass?
- ❑ Why volume is important
  Where does he volume of a sound come from?
  Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

- ❑ How sound travels
  Where does sound come from?
  Where does sound go?
- ❑ How or why distance matters
  What happens to sound as it goes farther from the source?
  Why does the singer need to be close to the glass?
- ❑ Why volume is important
  Where does he volume of a sound come from?
  Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

- ❑ How sound travels
  Where does sound come from?
  Where does sound go?
- ❑ How or why distance matters
  What happens to sound as it goes farther from the source?
  Why does the singer need to be close to the glass?
- ❑ Why volume is important
  Where does he volume of a sound come from?
  Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

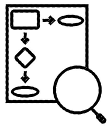
- ❑ How sound travels
  Where does sound come from?
  Where does sound go?
- ❑ How or why distance matters
  What happens to sound as it goes farther from the source?
  Why does the singer need to be close to the glass?
- ❑ Why volume is important
  Where does he volume of a sound come from?
  Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

- ❑ How sound travels
  Where does sound come from?
  Where does sound go?
- ❑ How or why distance matters
  What happens to sound as it goes farther from the source?
  Why does the singer need to be close to the glass?
- ❑ Why volume is important
  Where does he volume of a sound come from?
  Why does the singer have to be loud?

Lesson 7 Stop that Sound!

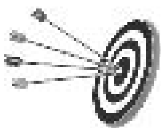


Purpose

This lesson focuses students on how sound energy transfers through various materials. As it moves through matter, sound energy can be reflected (echo) or absorbed (muffled). The material causes one or the other to happen to varying degrees. In this lesson, students will...

- Describe patterns between insulating materials and decibel readings.
- Explain results using knowledge that matter is made of particles as part of the unobservable process of absorbing or reflecting energy.
- Draw conclusions about the relationship between decibels (amplitude/volume) and properties of various materials.

This lesson provides some new information to students through non-fiction text, paired with a physical experience to help students make sense of sound as energy. For more about supporting ongoing changes in student thinking, see http://AmbitiousScienceTeaching.org



Learning Target

Focus Questions

Why can we hear noises from the hallway when we are inside the classroom? How can we stop sound energy?

Learning Target

I can design a device that blocks sound from transferring out of a box.

**You do not need to post a target statement. Instead, pose a question on the board.*

NGSS 3-D

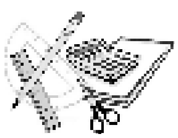
SEP: Ask Q's & Define Problems *Define simple problem solved by tool, process, system; addresses criteria & constraints*

SEP: Plan & carry out investigations
Make observations to produce data to serve as basis for evidence

PS3.A: Definitions of Energy

LS1.D: Information Processing

CCC: Systems & System Models
A system can be described in terms of its components and their interactions

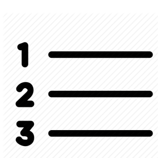


Materials

For the class:
- Video: snare drum (link)
- chart paper and markers

Per student group:
- empty pencil box
- two 1.5 volt AA batteries
- AA battery holder
- 1 piezo buzzer
- 1 decibel meter

Materials table:
- electrical tape
- assorted materials (examples: cotton balls, popsicle sticks, pencils, felt, tissues, foam, balloons, paper, marshmallows, cubes, marbles, packing peanuts, corks, coins)

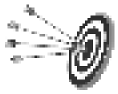


Lesson Step Summary

Part 1: Designing and testing solutions (45 mins)
1. **Frame:** Connect to an idea about sound traveling or moving
2. **Mini-Lesson:** Watch and discuss snare drum video using information about how sound energy travels through matter from L5.
3. **Explore**: Student teams make their plans with materials available and start testing and refining plans.
4. **Summarize:** Quick write about observations on their team plan and testing so far with ideas about what to try next.

Part 2: Analyzing data & summarizing learning (45 mins)
If needed, complete the summarize step on the next day in a 15 mins time
1. **Explore**: Test and finalize buzzer box sound-blocking designs.
2. **Data Collection**: Have each group officially test their box in front of the class and add to a class data table. Analyze and discuss trends.
3. **Model-to-Explain**: Give students a few minutes to model results.
4. **Summarize**: What did we do? What did we learn? Connect to the singer.

Part 1: Designing and testing solutions



Purpose

1. Framing: Orienting students to today's concept(s).

Open with a connection to a student's idea or noisy place problem about sound bouncing, echoing, or traveling that students recognized that the sound needs to stop. Tell students to think about this question then turn-and-talk: *Why can we hear noises from the hallway when we are inside the classroom?*

Watch Video

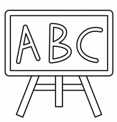
2. Just-in-Time Instruction: Analyze Snare Drum Example

Watch and discuss [this video of a snare drum] sound in an insulated room.

- How does the sound change?
- What causes the sound to change?
- How do you think the foam makes the sound different than on the walls?

Turn-and-Talk

Students may use the terms echo, bounce, absorb, or trap. Introduce the terms **echo** and **absorb** using students' own language and meanings.



New Terms

Connect back to the particle arrangement discussions in matter from L5.

- Why do hard surfaces like walls bounce sound but foam absorbs sounds?
- If we want to block or stop sound, what kinds of materials or properties in a design might help slow or stop the sound energy? Give silent think time.

Teamwork

3. Explore: Plan, test, and refine buzzer box sound-blocking design.

a. Tell students their challenge is to block a buzzer sound from escaping a closed pencil box. Place a buzzer connected to a battery inside a pencil box to see/ hear the set-up. Take an initial decibel reading.

b. Have students preview materials. Then, students make plans for what would block the sound, as measured by a decibel meter outside the box.

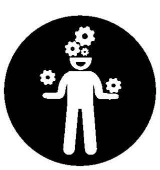
c. Once a team decides on a plan, they gather materials and begin doing some preliminary building-and-testing with final measurements in Part 2.

Criteria are things the design needs to do to be successful.

Design Criteria

The design must:

- Fit inside a closed pencil box
- Use materials in the classroom
- Include buzzer-battery circuit
- Decrease sound energy by at least 20 decibels



Management Tips

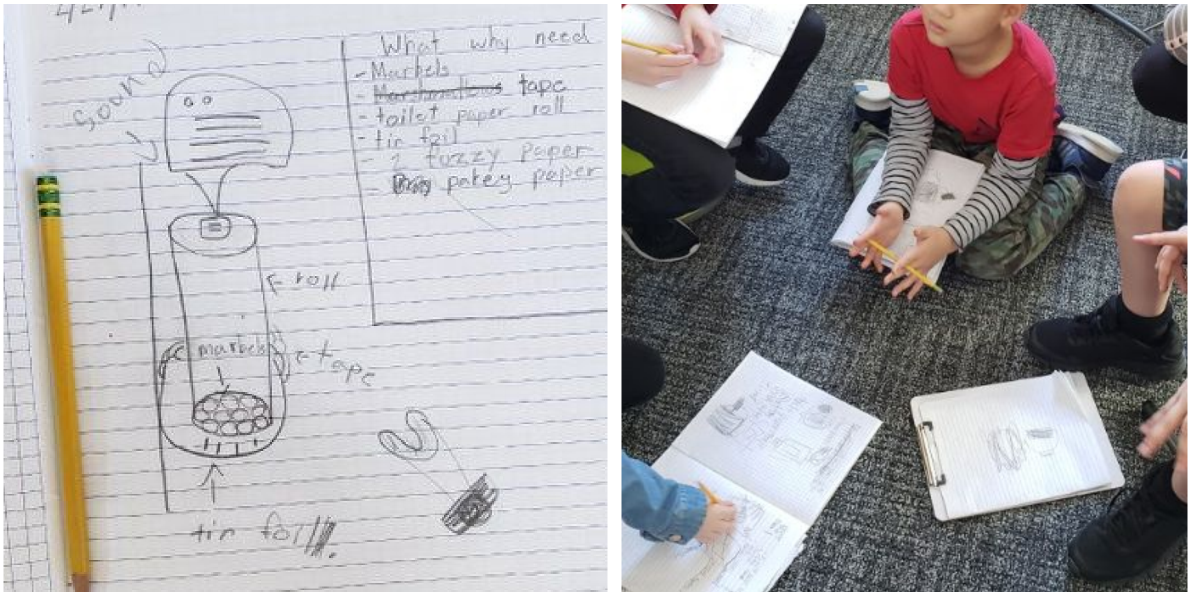
Teamwork Management Tips

- Have students quick sketch of 3 different ideas before meeting as a group.
- Acknowledge that compromising to work as a team can be hard. Give students language to navigate combining ideas, such as:
  - *We have different ideas, but could we combine these ideas?*
  - *Should we test both ideas and see which one we want to use?*
  - *I think your idea will block more sound because…*
  - *Your idea made me revise my idea. What if we tried…?*

Quick Write

4. Summarize: Quick write about design so far.
Have students do a silent quick write about what they did today, what they observed, and what changes or tests they want to try next. Remind students that tomorrow, after about 10 minutes of finalizing designs with their team, they will do the official decibel readings for each design group by group.

Photos from Lesson 7, Part 1



Groups worked together to make a plan to test they all agreed on and how to make it. Before building the teacher checked in that each group member agreed to the plan and knew reasons behind materials selection.

In another group, a student takes a baseline decibel measurement of the Piezo buzzer before packing it inside their pencil box to test their design which used stale marshmallows and aluminum foil.

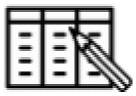
Part 2: Analyzing data & summarizing learning

Teamwork

1. Explore: Finalize designs

Give teams about 5-8 minutes to finalize their designs.

2. Collect & analyze data



Collect Data

Have each group bring their design to the front and test with no other noise interference. Jot data on the board including the materials in the buzzer box and the decibel reading with the box closed. Compare to the original reading with the closed empty box from Part 1.

Materials	Decibels	Decrease
Buzzer only	94.6	X
air only, closed box	91.2	X
Foam peanuts In cardboard tube	78.1	13.1
Stale marshmallows	88.6	2.6
Balled up tissues compacted	72.0	19.2

Analyze data

Analyze the data:

- How much did each design decrease sound energy exiting the box?
- What does the data say about how to best reduce sound energy?
- Does this data help answer our question: *Why can we hear noises from the hallway when we are inside the classroom?*

Model to Explain

3. **Model-to-Explain**: Which materials block sound best? How come?

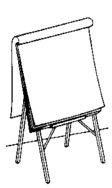
Tell students that they will have a few minutes to develop a model showing how the sound energy from the buzzer travels through matter and how it is blocked. They can choose any materials to explain based on data from the class data table. Have students share in pairs.

Share & Discuss

4. Summarize: Discuss and summarize learning

Give think time and a few minutes of discussion going one column at a time, spending the most time on learning and connections.

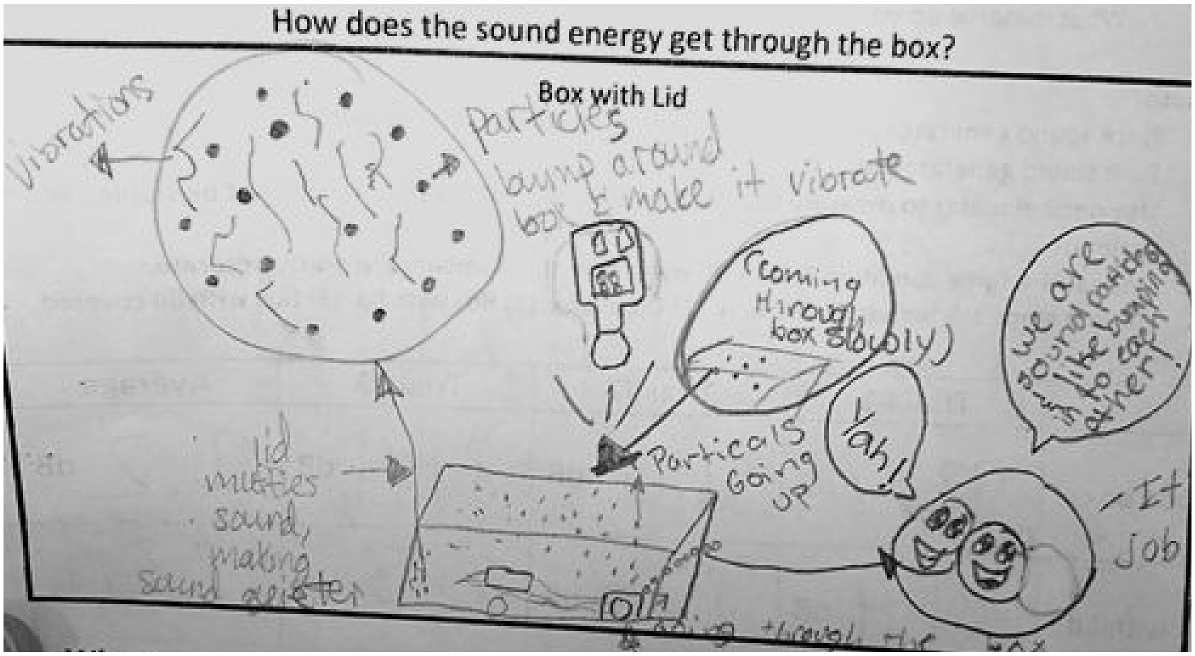
Decide on: What do we think is important about what we did? observed? and learned today? How does knowing about echoes, absorption, and material properties help us explain how the singer could shatter the glass?



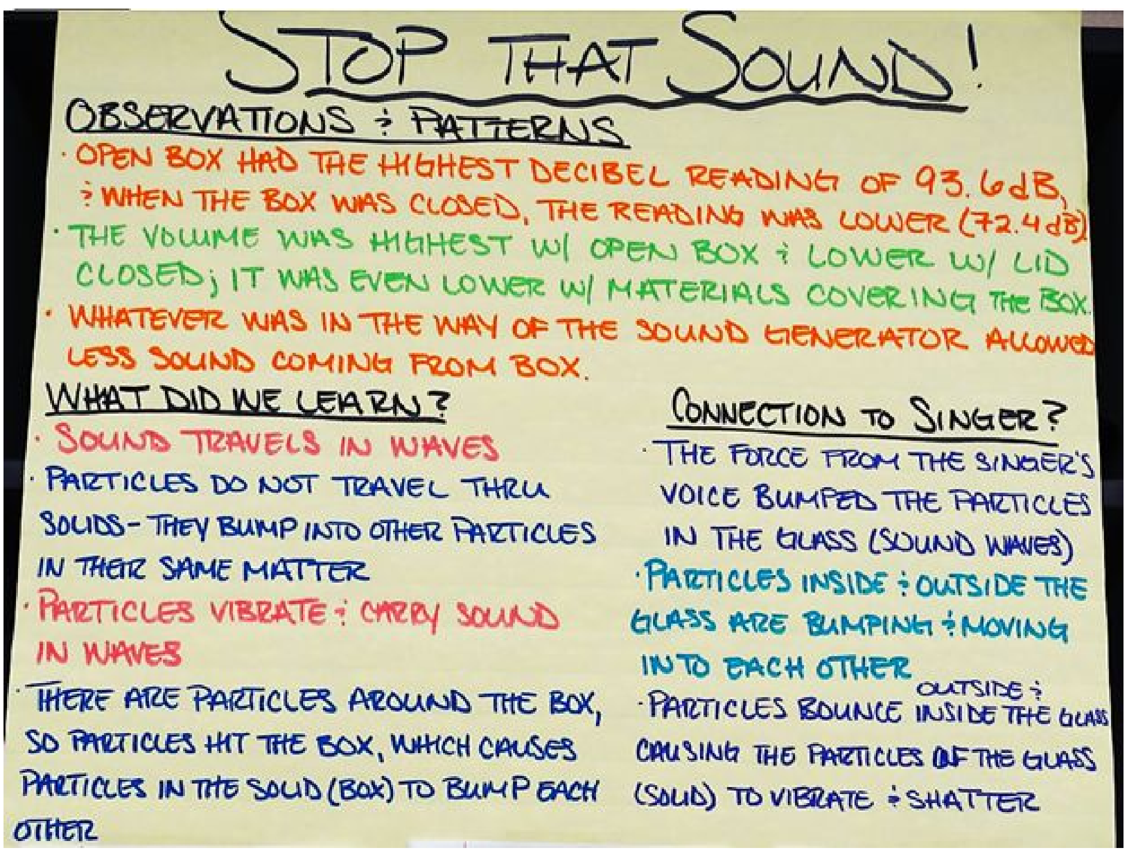
Summary Table

Investigation	Observations	Learning	Connections
What did we do? What were we figuring out?	What patterns did we notice between materials and decibels?	How can we explain patterns in the data? What questions do we have about energy? matter?	What does this have to do with explaining why the singer was able to shatter the glass?

Photos from Lesson 7, Part 2



Student model explaining how sound travels through the box without any stuffing or materials but focusing on the air in the closed box. (The teacher said students could choose to include the materials or not as some students were interested in modeling echoes more than absorption.)



Summary chart example from this lesson. The teacher summarized bullets from the whole-class discussion. Alternatively, the teacher could have student(s) be the scribe(s) to write on the chart.

Reflections & Notes

Lesson 8 Find the Right Pitch: Learning about Resonance

Purpose

This lesson focuses students on how vibrating things make sounds and also that one object can vibrate another object with less force when vibrating at the right pitch, or resonant frequency.

Learning Target

Focus Questions
How can one object make another object vibrate without touching it?

Learning Target
I can make observations to identify a cause-and-effect relationship using an understanding of pitch and resonance.

NGSS 3-D
SEP: Plan & carry out investigations *Make observations to produce data to serve as basis for evidence*
PS4.A: Wave Properties *Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks)*
Cause & Effect *Cause & effect relationships are routinely identified and used to explain change*

Materials

Video: Grandpa John (link)
Video: Singer shatters glass (link)
For class demonstrations:
- Glass bowls - 2 or 3 sizes
- Saran wrap (cover bowl like a drum)
- Salt shaker
- Safety glasses
- Resonance boxes w/mallet

Student half sheet (link)

For optional extensions:
- *construction paper*
- *scissors*
- *spaghetti, dried pasta*
- *small marshmallows*
- *scalp massager, 1 per group (link)*

Lesson Step Summary

1. **Frame:** Connect to an idea or question students had about why the singer flicks the glass and/or why the singer only sings on one note or pitch.
2. **Explore:** Watch, make observations, compare and discuss two examples of resonance--glass bowls and resonant tuning fork boxes.
3. **Model-to-Explain**: Student compare and model-to-explain the similarities and differences between the glass bowl example and resonant boxes.
4. **Summarize:** Revisit and discuss today's focus question: *How can one object make another object vibrate without touching it?*

Optional extension: Read and explore more about the importance of understanding resonance in the design of buildings and bridges (earth science connection with soil properties and earthquakes as mechanism for transferring energy)

Lesson Steps

Purpose

Turn-and-Talk

1. Framing: Orienting students to today's concept(s).

Connect to an idea or question students had about why the singer flicks the glass and/or why the singer only sings on one note. Tell students to think about this question then turn-and-talk: *Why do you think the singer flicked the glass?* If helpful, revisit the opening few seconds of the singer video clip.

Once the singer started singing, he made the glass vibrate, which they can hear after his first attempt. The glass doesn't break and when he breathes you can hear the glass humming (0:06-0:09). So, today's question is: *How can one object make another object vibrate without touching it?*

Observations

Watch Video

Share & Discuss

New Terms

Turn-and-Talk

2. Explore: Analyze & compare glass bowl/tuning fork examples

a. Cover a glass bowl with plastic wrap to make a tight surface. Sprinkle some salt on the top of the plastic wrap. Wear safety glasses (to avoid blowing salt in eyes). Hum loudly at different pitches, like an airplane taking off, with lips within 6 inches from the edge of the bowl. Stop at the pitch that makes the salt jump. Try that pitch again with more force. Have students make observations.

b. Try this with different sizes of glass bowls:
- What do you notice about the size of the bowl and the pitch that makes the salt dance?
- What does the salt dancing indicate or show?

c. Watch and make observations from this video explaining resonance using tuning forks. What did Grandpa John do? Why did it work? *If available, use resonance boxes in class to hear and feel vibrations for tuning forks on the same pitch.*

d. Introduce the term **resonance** and/or **resonant frequency**.

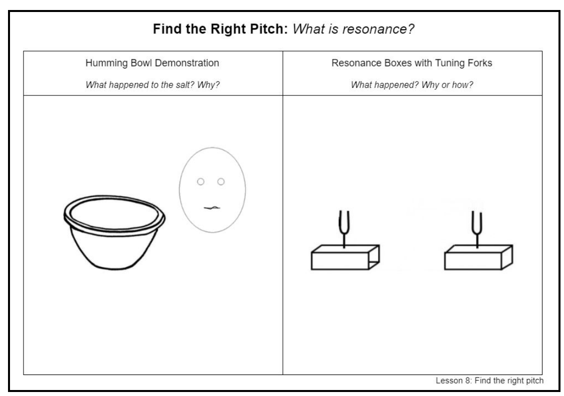
e. Have students compare the humming bowls with the tuning forks.
- What's similar in these examples? *Possible responses: Both use one sound/pitch. Both make something vibrate at close distance without touching.*
- What's different? *Possible responses: Different materials (glass vs metal/wood), different sources of vibration (voice/hum vs other tuning fork)*

3. Model-to-Explain: How does resonance work?

Model to Explain

Have students use what they know about what matter is made of and wave representations to explain how resonance works (optional: [student half sheet template]).

What might be going on that we can't see with the air particles or particles in the objects or table that helps explain how these waves of energy travel?


Find the Right Pitch: *What is resonance?*

Humming Bowl Demonstration *What happened to the salt? Why?*	Resonance Boxes with Tuning Forks *What happened? Why or how?*

Lesson 8: Find the right pitch

Summarizing Learning

4. Summarize: Discuss today's focus question.

Have students think and then discuss what today's observations about the bowls and tuning forks have to do with the singer flicking the glass.

[Possible connection: The singer flicks the glass to hear the glass' natural resonant pitch. He sings at that pitch which makes the glass hum. He wouldn't need to sing at the 'right' pitch if he could be super duper loud (like an explosion) that would break the glass without being on the right pitch. Being at the right pitch helps him break the glass along with the force he is able to put into it. If not at the right pitch, the singer probably couldn't make enough force with his body to break it.]

Optional Extension: Why is resonance important?

Extend & Follow-up

Students can read and learn more about why understanding resonance is important in engineering.

Mechanical resonance can produce vibrations strong enough to destroy the object in which they occur. For example, soldiers marching over a bridge can set up extreme vibrations at the bridge's natural frequency and shake it apart. For this reason soldiers break step to cross a bridge. In 1940 wind gusts at Puget Sound Narrows, Tacoma, Washington, caused a suspension bridge to vibrate at its natural frequency and the bridge collapsed.

More on resonance:

- https://popphysics.com/chapter-6-waves-and-sound/resonance/
- http://www.science4all.org/article/resonance/ → scalp massagers
- https://www.exploratorium.edu/snacks/resonant-rings
- https://www.exploratorium.edu/snacks/spaghetti-resonance

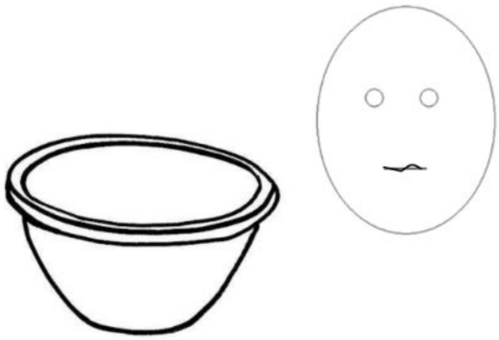
Tacoma Narrows bridge collapse due to resonance:

- https://www.forbes.com/sites/startswithabang/2017/05/24/science-busts-the-biggest-myth-ever-about-why-bridges-collapse/#5d865d891f4c

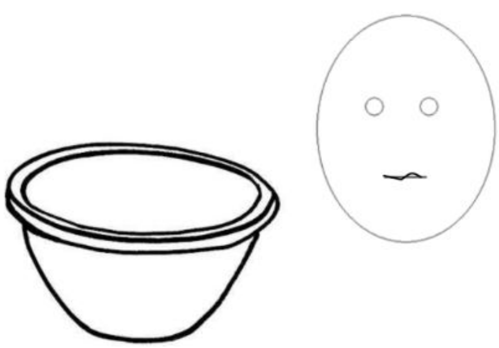
Building size and soil material determines a resonant frequency that can be matched often by wind and/or earthquakes and must be addressed by engineering solutions:

- https://www.iris.edu/hq/inclass/animation/building_resonance_the_resonant_frequency_of_different_seismic_waves (Open the 5 min 30 sec video and start watching at 2:30)

Find the Right Pitch: *What is resonance?*

Humming Bowl Demonstration *What happened to the salt? Why?*	Resonance Boxes with Tuning Forks *What happened? Why or how?*
	

Find the Right Pitch: *What is resonance?*

Humming Bowl Demonstration *What happened to the salt? Why?*	Resonance Boxes with Tuning Forks *What happened? Why or how?*
	

Lesson 8: Find the right pitch

Lesson 9 Sound Energy vs Moving Air

Purpose

This lesson provides students with an opportunity to clarify their understanding of energy and matter by considering the difference in motion of air molecules between what sound energy and wind motion.

Learning Target

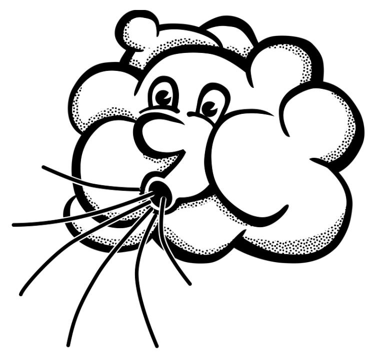
Focus Questions
Why can we hear the spray sound before we can smell the fragrance?

Learning Target
I can develop a model to explain how energy travels through matter.

NGSS 3-D
SEP: Develop and use models *Develop a model to describe phenomena*
PS1.A: Structure and Properties of Matter *Matter of any type can be subdivided into particles too small to see*
PS3.A: Definitions of Energy *Energy can move from place to place by moving objects or sound*
Energy and Matter: Flows, Cycles, and Conservation *Energy can be transferred in various ways & between objects*

Materials

For class demonstration:
- Summary charts from prior investigations
- 1 can aerosol spray bottle of scented air freshener



Lesson Step Summary

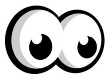
1. **Frame:** Air freshener spray demonstration - *How can we hear the spray before we smell the fragrance?*
2. **Just-in-time instruction:** Review and locate helpful information from past investigation to help explain this phenomenon.
3. **Model-to-Explain**: Use bodies to represent molecules in the air and act out the room spray phenomenon.
4. **Summarize:** Revisit and discuss today's question: *How can we hear the spray sound before we can smell the fragrance? What does this have to do with the singer breaking the glass?*

Lesson Steps

Safety Alert

The demonstration involves spraying scented air freshener. Check that students do not have allergies or sensitivities to a small amount of fragranced room spray. *Alternative: Do the talk-to-the-hand demo described in 1a below.*

1. Framing: Orienting students to today's concept(s).



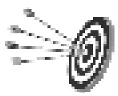
Observations

a. Have students spread out in the room. Teacher stands in the corner with a bottle of fragrance spray. Tell students to raise their hand as soon as they hear the "spritz" sound and then to lower their hand once they smell the fragrance. *What did you notice? Who could smell it first? hear it first?***

***Alternative:* Talk to your hand: Have students hold a hand eight inches from their mouth. Blow at your hand without making a sound. Feel the air. Now make a sound like "Aaaaa" at your hand. They should observe that they can make sounds without feeling moving air and they can make air move without making sound. *What's going on?*

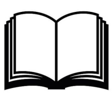
Turn-and-Talk

b. Talk with a partner about observations and share ideas about why we hear the spritz sound before we could smell the fragrance.



Purpose

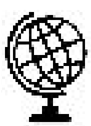
c. Introduce today's purpose *How can we hear the sound of the room spray spritz before we can smell it?* What does this tell us about how energy moves versus how matter moves?* [*Student questions about if sound and air/wind are the same or different could be connected here as well.]



Locate Information

2. Just-in-Time Instruction: What information do we need?

Ask students what they have learned so far in this unit that might help with this question. Have students locate and review information from the notes and readings in their science notebooks and from summary charts and past investigations to review what they know about molecules in matter.



Physical Model

3. Model-to-Explain

Physically model molecules in the air with their bodies: Have 4 students stand side-by-side and feeling the wave of energy (push) students like students did in L4. Get student input to act out the room spray scenario.

- *How can we change this wave model, where people are still molecules in the air, to better represent our fragrance spray scenario?*
- *What do we need to add or change about this model to better represent what is happening to explain how we can hear the sound before we smell the fragrance?*

Set a rule that bodies only represent matter/molecules of "stuff".

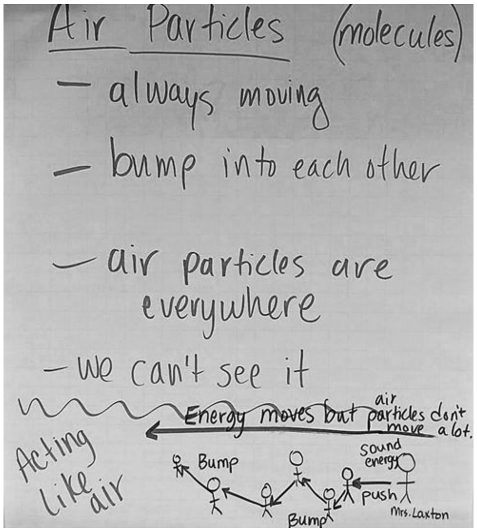
- What matter are we adding to the room? (fragrance droplets, spray)
- What energy are we pushing into the room? (sound)
- So if sound is not matter, how can we represent sound energy? (body movement/bumping)

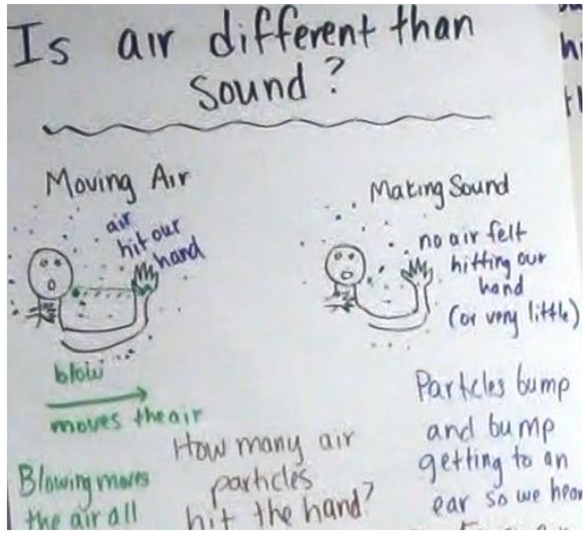
Summarizing Learning

4. Summarize: Discuss today's focus question.

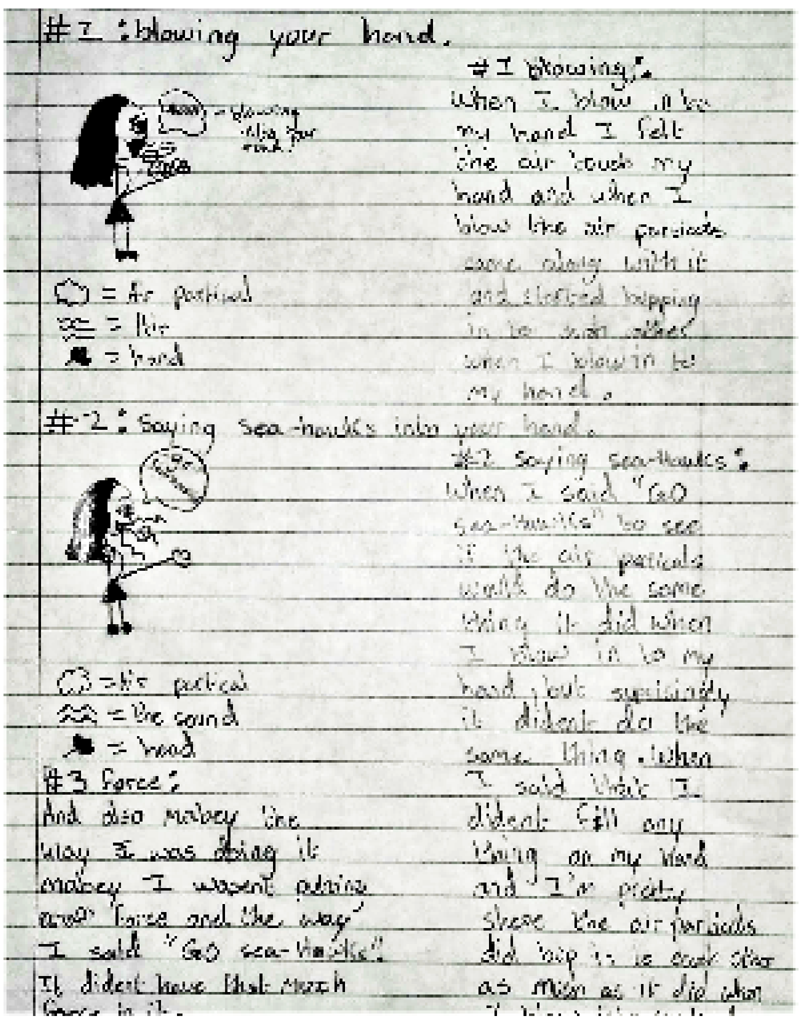
Have students consider what today's observations and discussion have to do with the singer flicking the glass. *[Possible connection: The singer makes air molecules bump into each other not by blowing like a hurricane, rather singing at the right pitch making air molecules hit glass in a rhythm to crack it.]*

Photos from Lesson 9





Anchor charts from this lesson from two different classrooms summarizing what students shared about what they know about molecules and how sound is different than air.



Student wrote:
#1: blowing your hand.

#1: blowing:
when I blow into my hand I felt the air touch my hand and when I blow the air particals came along with it and started bumping into each other when I blow into my hand.

#2: saying sea-hawks into your hand.

#2 saying sea-hawks:
When I said “Go Sea-Hawks” to see if the air particals would do the same thing it did when I blow into my hand, but surprisingly it dident do the same thing. When I said that I dident fill any thing on my hand and I’m pretty shere [sure] the air particles did bop into each other as much as it did when I blow into my hand.

And also mabey the way I was doing it maybe I wasent putting enuff force and the way I said “Go sea-hawks”. I dident have that much force in it.

Student quick-write: The difference between how molecules in the air move with blowing vs speaking.

Reflections & Notes

Lesson 10 Constructing Evidence Based Explanations

Purpose

This lesson provides an opportunity for students to take stock in what they have done and learned so far and use it to construct an evidence-based explanation of the unit phenomenon or related phenomenon..

- Students revise/develop explanatory models about the unit phenomenon about how the singer shattered the glass.
- Students draft and give feedback on evidence-based explanations of the phenomenon.

The purpose of this lesson is to help develop ideas to use to revise explanations and models for the phenomena. For more on supporting student sensemaking, http://AmbitiousScienceTeaching.org

Learning Target

Focus question

What evidence do we have for our current thinking? How can we use evidence to justify our ideas?

Learning Target

I can use evidence from text, video, and experiments to justify my ideas about why the glass shattered.

**You do not need to post a target statement. Instead, pose a question on the board.*

NGSS 3-D

SEP: Constructing Explanations *Use evidence (e.g., measurements, observations, patterns) to construct an explanation*

PS1.A: Structure & Prop of Matter *Matter of any type can be subdivided into particles too small to see*

PS3.A: Definitions of Energy *Energy can be moved from place to place by moving objects or sound*

Cause & Effect *Cause & effect relationships are routinely identified and used to explain change*

Materials

For the class:

- Summary charts from prior lessons/activities posted
- Students' initial models from L1
- Chart paper & markers
- *Optional: 4 colors sticky notes*

Per student:

- evidence-based explanation checklist quarter sheet (link)
- *Optional (see decision point): Blank model scaffold, or blank paper one per student (choose a version)*
- *Optional: claims & evidence sentence starter strips (link)*

Teacher decision point

There is no "right way" to support students in updating models. That said, if students used different colors of sticky notes to update their models in Lesson 6, it may be better to start from a blank model for this update so it does not get too busy or hard to follow. This model update in Part 1 will serve as a pre-writing for a more essay style explanation in Part 2 so it might be helpful to start from a blank page or blank model template. Use your discretion to best support all of your students in making current thinking visible.

Lesson Step Summary

Part 1: Update checklist and revise models

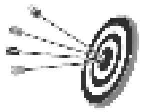
1. **Launch:** Update/revise explanation checklist
2. **Explore:** Update/revise model addressing all checklist items
3. **Mid-point pause:** Partner power for checklist check-in.
4. **Summarize:** Pressing for evidence

Part 2: Persuading others with evidence

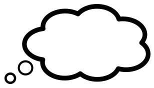
1. **Launch:** How do we know what we know?
2. **Mini-Lesson:** Writing with evidence convincingly; Introduce sentence starters as optional scaffold for students to use
3. **Explore:** Draft evidence-based explanation
4. **Summarize:** Peer feedback about their use of evidence. Does the evidence support the claim? Could it be written more specifically?

Add additional time as needed to complete the evidence-based explanation.

Part 1: Update the explanation checklist and revise/develop models

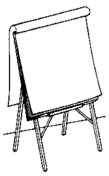


Lesson Purpose



Think Time

Turn-and-Talk



Update Checklist

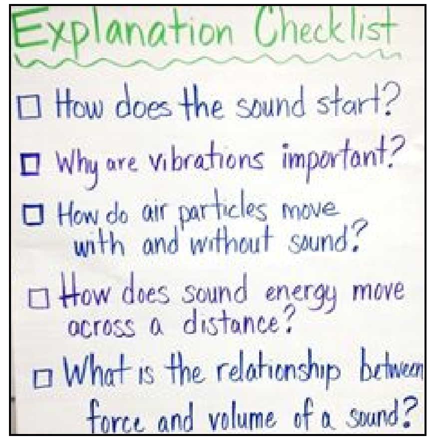
1. Frame: Activate and connect to students' prior experiences

Tell students that today they will take stock in everything they have done so far as this unit.

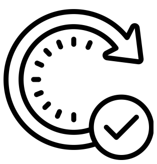
Have students read the checklist they created in L6 and look around the room at the summary tables and in their notebooks to come up with proposed additions or revisions to the checklist. Share with a partner.

Update and add to the explanation checklist. This list helps remind students what ideas are important to include and address when explaining any sound energy phenomenon, not just the singer breaking the glass.

What do we need to consider when explaining any sound energy phenomenon?



What would students add or change about the explanation checklist now?



Update ideas

Back-Pocket Questions

2. Explore: Update Models

Students work on their models making sure to address the items on the explanation checklist.

Circulate as students work to notice how they are using what they have learned in their models. As needed, do a whisper conferences to support student engagement in the task.

Back-pocket Questions:

- How have your included __ from our checklist in your model?
- I see you have labeled ___. What else could you add to show why that is important to the story?
- Can you tell me what role ___ play in your explanation so far?
- How does this part about ___ fit with the rest of your model?

Clarifying Ideas

3. Mid-point Pause: Checklist check-in.

You may notice some checklist items are easily addressed while others seem more challenging. Use this pause for students to work on a challenging checklist item with a partner. Have students pair up and decide on one checklist item to focus on together, preferably one they find hard or challenging. They use partner power to figure it out together.

Think about and ask each other:

- What do we know about this idea?
- Where could we find information to remind us about this idea? What did the reading, notes, or summary chart say about it?
- Why is this idea important?
- How can we show this in our model?

Students update on their own models about this checklist item.

Compare & Connect

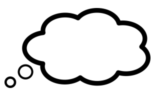
4. Summarize: Compare & Connect, Pressing for Evidence

Bring the class together and ask for volunteers who can show an example of how they addressed one item on the explanation checklist. Take turns and add on. The move to the next checklist item. You do not have to go through all the checklist items but focus on 1 or 2. Students may have more than one way to show the same idea.

Ask students, *"How do you know?"* or "*What did we do, read, or watch that helped you understand that idea?"* These questions preview the push for evidence in Part 2.

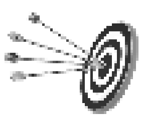
Part 2: Persuading others with evidence

1. Frame: Activate and connect to students' prior experiences



Think Time

Turn-and-Talk



Lesson Purpose

Provide a claim like the one at right (or have students choose one from their model) that the class generally agrees on and ask themselves:

What evidence do we have for this idea? Where can we look to remember the evidence we have?

Have students share with a partner and then share out to the class the different sources of evidence that would support this claim.

Today students will support ideas with evidence to persuade others their claims are accurate.

Example claim: Point to a drawn model showing the change in energy over distance moving away from the sound and say something like: *I know that the farther away from the source of the sound, there is less energy so it sounds quieter. This happens because at first the energy is concentrated at the source and then the energy goes out in all directions through the air.*

Students may suggest vague, non-specific evidence like…

- We did/heard it.
- We bumped into each other like molecules and the bump got less.
- We know this because I can't hear people far away when they're talking

2. Mini-lesson: Writing with evidence

Mini Lesson

Tell students that scientists convince others that their ideas are accurate by using evidence*.* Remind students they have evidence (see summary charts) from taking measurements, making observations, and from reading texts and watching video they can draw from and use in their explanation.

The checklist at right (link to ¼ sheet) might help students include specific descriptions, examples, details and connections to clearly explain their claim. Students could also use the sentence strips to help them organize their writing.

Writing evidence-based explanations:

- ❏ I wrote my idea or claim clearly:
  - Used specific words (not "it")
  - Used complete sentences
  - Gave a real-world example
  - Defined science words I used with synonyms or phrases to help the reader know what I mean
- ❏ I explained how or why I think my claim is true (or when it is not) using science concepts
- ❏ I supported my claim with evidence:
  - data patterns
  - quotes from text or video
  - detailed personal experience
- ❏ I told the reader why or how this evidence supports my claim.

Science Writing

3. Explore: Write with evidence

Circulate as students work. Students begin drafting their evidence-based explanation, starting with one claim or idea and moving on from there. Encourage students to use their models as a pre-writing organizer. *What ideas did they show? Which ideas do they have evidence for?*

Look for some students who have examples they could add or clarify more and who might be willing to use their work in the whole-class peer feedback task next.

4. Summarize: Peer feedback

Share & Discuss

Have volunteers show their explanation under the document camera. Focus around one claim + evidence paragraph or section. Have students use the "writing evidence-based explanation" checklist to identify items the author has included and/or done well. Then students turn to a partner and decide on one area for feedback or improvement to suggest.

As time permits, have students do this kind of feedback routine for their explanation with a partner at their table group and then add or attend to feedback today or in a next shorter session to wrap up working on explanations. *(Remember improving how to write evidence-based explanations takes time and opportunities to practice, receive feedback, and decide how to address the feedback).*

Analyzing Student Work

Look for evidence of understanding of the following key science ideas from recent lessons as you examine students' updated models.

- How many students attended to these **ideas**?
    - Energy can be transferred from one place to another. Waves transfer energy.
    - How or where the sound energy changes over a distance
    - Vibrating matter creates a sound wave that moves energy and makes sound.
    - Recognizes that energy is present and moving in waves when there is sound.
    - Include properties of the sound wave (amplitude, pitch, wavelength, etc) to explain how or why this particular sound can break the glass.
    - How sound transfers through matter, like air or glass

    - If they included an idea, to what degree did they demonstrate their understanding? Did they just label or mention a concept or did they use the concept to explain a mechanism or cause-and-effect process?

    - If they did not include an idea, was there scaffolding or resources that would have pointed them to include them or do you think students do not find them useful or applicable to the singer phenomenon?

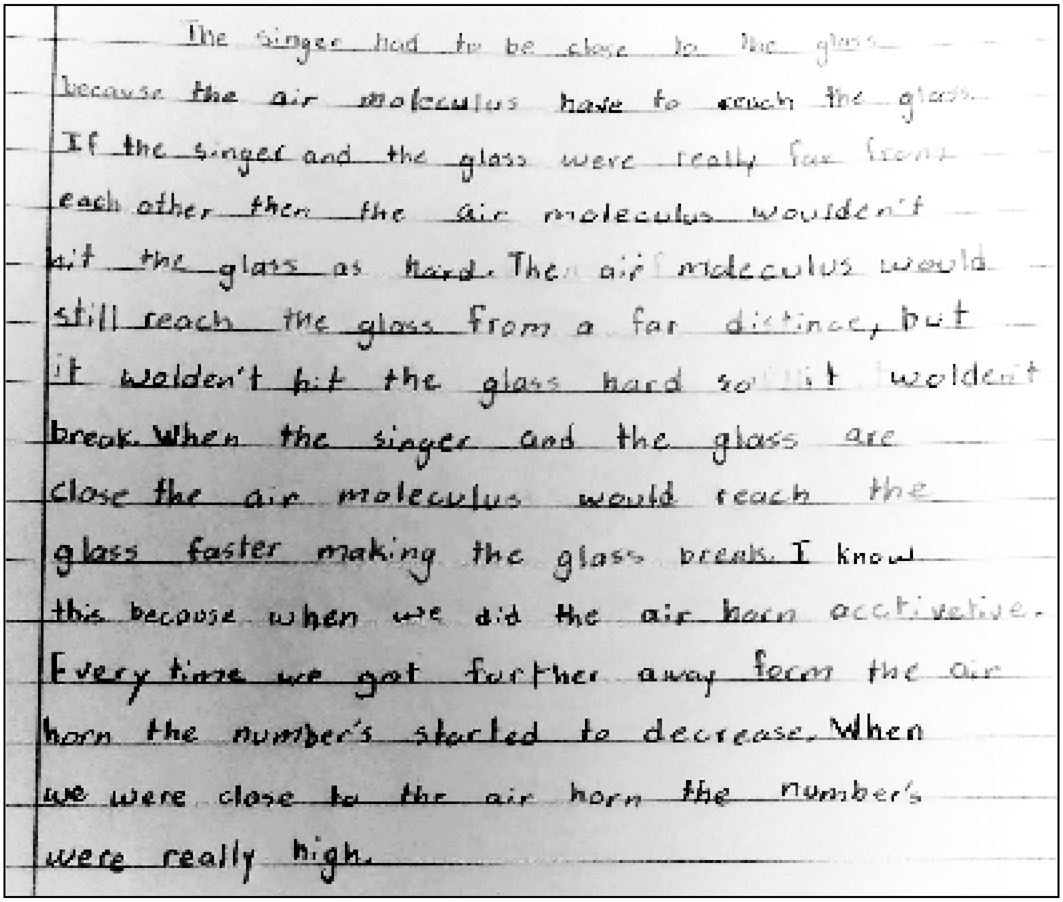
- How did students use **evidence** to support their ideas?

Remember students need many opportunities to practice writing with evidence and to give and receive feedback to improve how robustly they use evidence to support their claims. Eventually students will name, describe, use specific data, and say how this particular evidence supports the claim. Look for where and how students are using evidence to see what you can target in a future mini-lesson to support students developing their skill at writing with evidence.

Current performance & next steps	*Example*
1. Generalized claim connected to specific phenomenon. No mention of evidence. ☐	*The volume of a sound decreases the farther away we get from the source. That's why the singer has to be close to the glass.*
2. Name the source of evidence. ☐	*The volume of a sound decreases the farther away we get from the source. That's why the singer has to be close to the glass.* ***I know this because we did an experiment.***
3. Describes source of evidence. ☐	*The volume of a sound decreases the farther away we get from the source. That's why the singer has to be close to the glass. I know this because we did an experiment* ***measuring the sound of an air horn up close and far away.***
4. Includes specific evidence such as a data pattern or quote from the evidence source. ☐	*The volume of a sound decreases the farther away we get from the source. That's why the singer has to be close to the glass. I know this because we did an experiment measuring the sound of an air horn up close and far away.* ***We measured the sound of an air horn up close at 4 meters away and the sound was 94 decibels and we measured the sound again far away at 32 meters the sound was 72 decibels. The farther we got from the air horn, the less power the sound has.***
5. Includes more than one piece of specific, supportive evidence from more than one source. ☐	*The volume of a sound decreases the farther away we get from the source. That's why the singer has to be close to the glass. I know this because we did an experiment outside that showed the pattern that sound decreases the farther we get from the source. We measured the sound of an air horn up close at 4 meters away and the sound was 94 decibels and we measured the sound again far away at 32 meters the sound was 72 decibels. The farther we got from the air horn, the less power the sound has.* ***Also, in the reading titled "What is amplitude?" the author agrees with my idea because they included a diagram showing the amplitude of the sound wave decreases if no more energy is put into it saying that the sound is "fading over time as the sound energy spreads out into a room."***
6. Attempts to connect evidence to the claim	*The volume of a sound decreases the farther away we get from the source. That's why the singer has to be close to the glass. I know this because we did an experiment outside that showed the pattern that sound decreases the farther we get from the source. We measured the sound of an air horn up close at 4 meters away and the sound was 94 decibels and we measured the sound again far away at 32 meters the sound was 72 decibels. The farther we got from the air horn, the less power the sound has. Also, in the reading titled "What is amplitude?" the author agrees with my idea because they included a diagram showing the amplitude of the sound wave decreases if no more energy is put into it saying that the sound is "fading over time as the sound energy spreads out into a room."* ***This evidence from the experiment and the text connect my idea that the power or volume of a sound is related to the distance or how far away we are from the source because the sound energy spreads out. So the singer puts the most force or power from his sound onto the glass when he is as close to the glass as he can get without touching it.***

Photos from Lesson 10

Example A: Evidence-Based Explanation for a single claim --
Why does the singer need to be close to the glass?

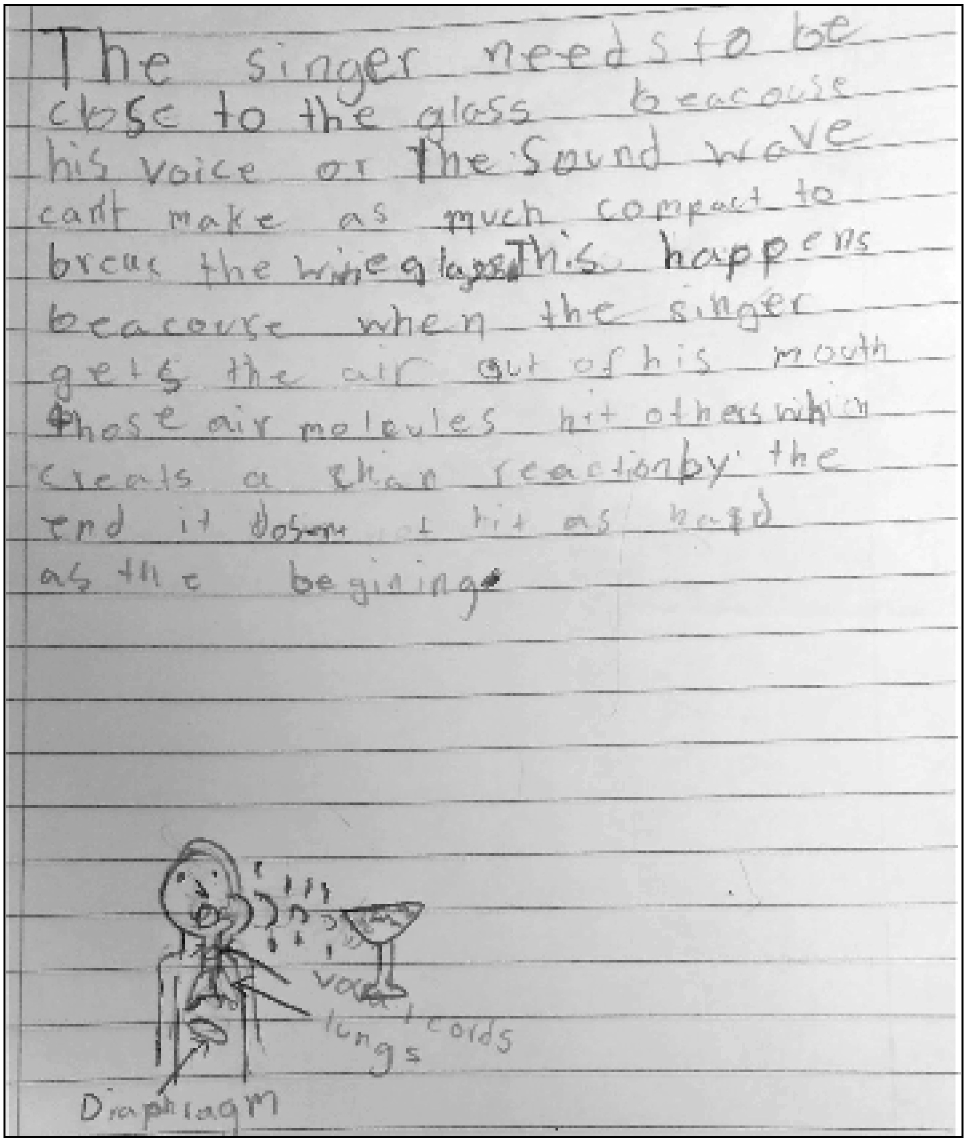

The singer had to be close to the glass
because the air moleculus have to reach the glass.
If the singer and the glass were really far from
each other then the air moleculus wouldn't
hit the glass as hard. The air moleculus would
still reach the glass from a far distince, but
it walden't hit the glass hard so it woldent
break. When the singer and the glass are
close the air moleculus would reach the
glass faster making the glass break. I know
this because when we did the air horn acctivetive.
Every time we got further away from the air
horn the number's started to decrease. When
we were close to the air horn the number's
were really high.

Example A:
"The singer had to be close to the glass because the air moleculus have to reach the glass. If the singer and the glass were really far from each other then the air moleculus wouldn't hit the glass as hard. The air molecules would still reach the glass from a far distince, but it wouden't hit the glass hard so it wolden't break. When the singer and the glass are close the air moleculus would reach the glass faster making the glass break. I know this because when we did the air horn acctivetive [activity]. Every time we got further away from the air horn the number's started to decrease. When we were close to the air horn the number's were really high."

Feedback on Example A:
Some feedback for this student would be to recognize what is going well so far: This student makes a clear claim (sentence 1) using the science idea of air molecules to explain why sound changes over distance, gives a comparison example far vs near (sentences 2-4), names the source of evidence (sentence 6), includes a pattern from an experiment as evidence (sentences 5-6). Then suggest some next steps:

- Clarify what molecules "not reaching" means -- Do they mean a single individual molecule is traveling or that the bumping is not reading?
- Adding a sentence connecting back to the original, opening claim in the paragraph and saying directly how the evidence supports this claim

Example B: Evidence-Based Explanation for a single claim --
Why does the singer need to be close to the glass?

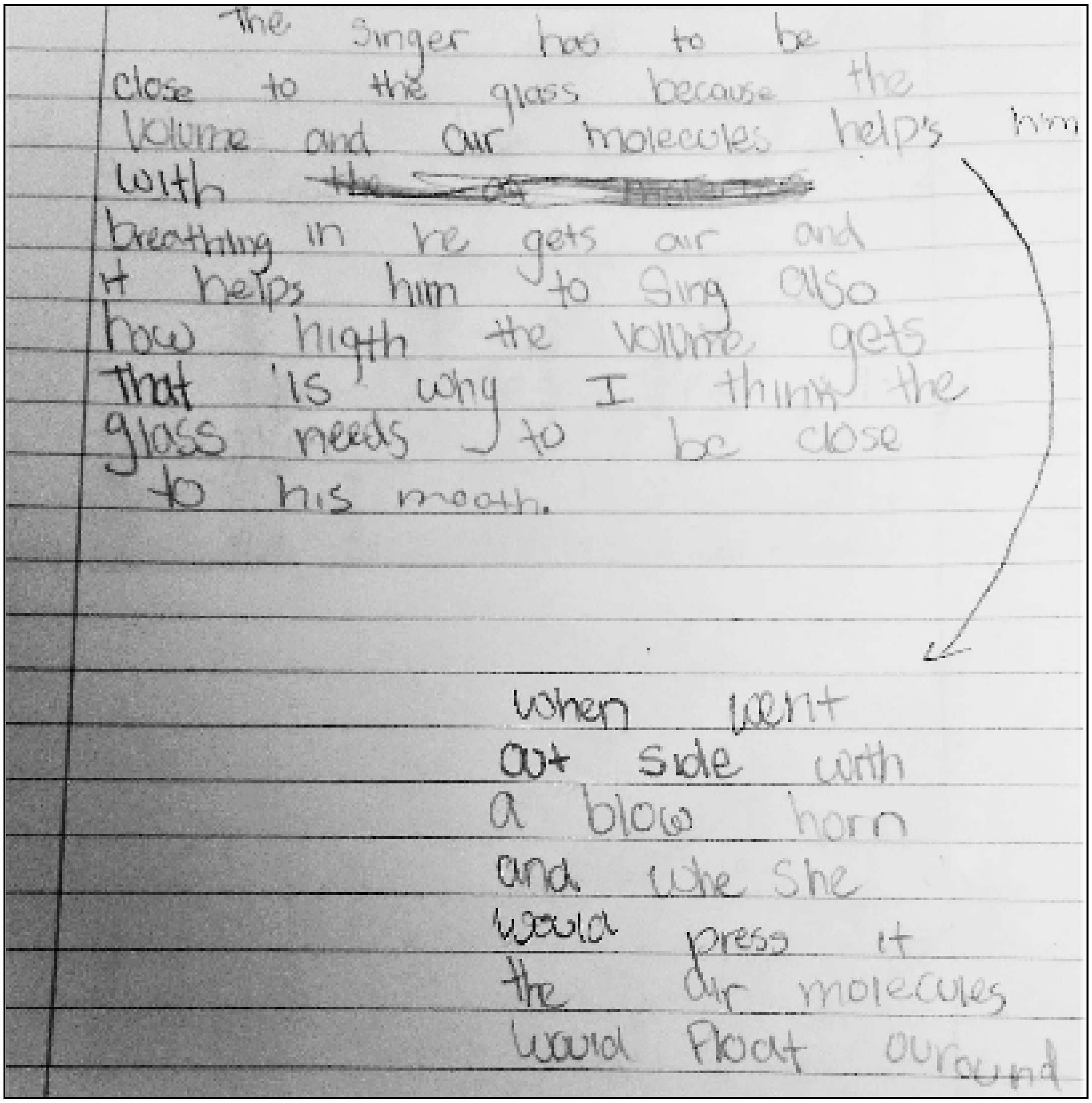


Example B:
“The singer needs to be close to the glass because his voice or the sound wave can’t make as much compact to break the wine glass. This happens because when the singer gets the air out of his mouth those air molecules hit others which creates a chain reaction by the end it doesn’t get hit as hard as the beginning .”

Feedback on Example B:
Some feedback for this student would be to recognize what is going well so far: This student makes a claim and uses knowledge of molecules to explain more about the unobservable mechanism about how this happens. Then suggest some next steps:

- Clarify “chain reaction” in case the reader did not understand that phrase which would also clarify, “by the end it doesn’t get hit as hard as the beginning.”
- Add evidence for the idea. How do you know about air molecules? How do you know that sound bumps molecules in the air in this chain reaction? Name the source and include some quotes or data to support the claim.

Example C: Evidence-Based Explanation for a single claim --
Why does the singer need to be close to the glass?

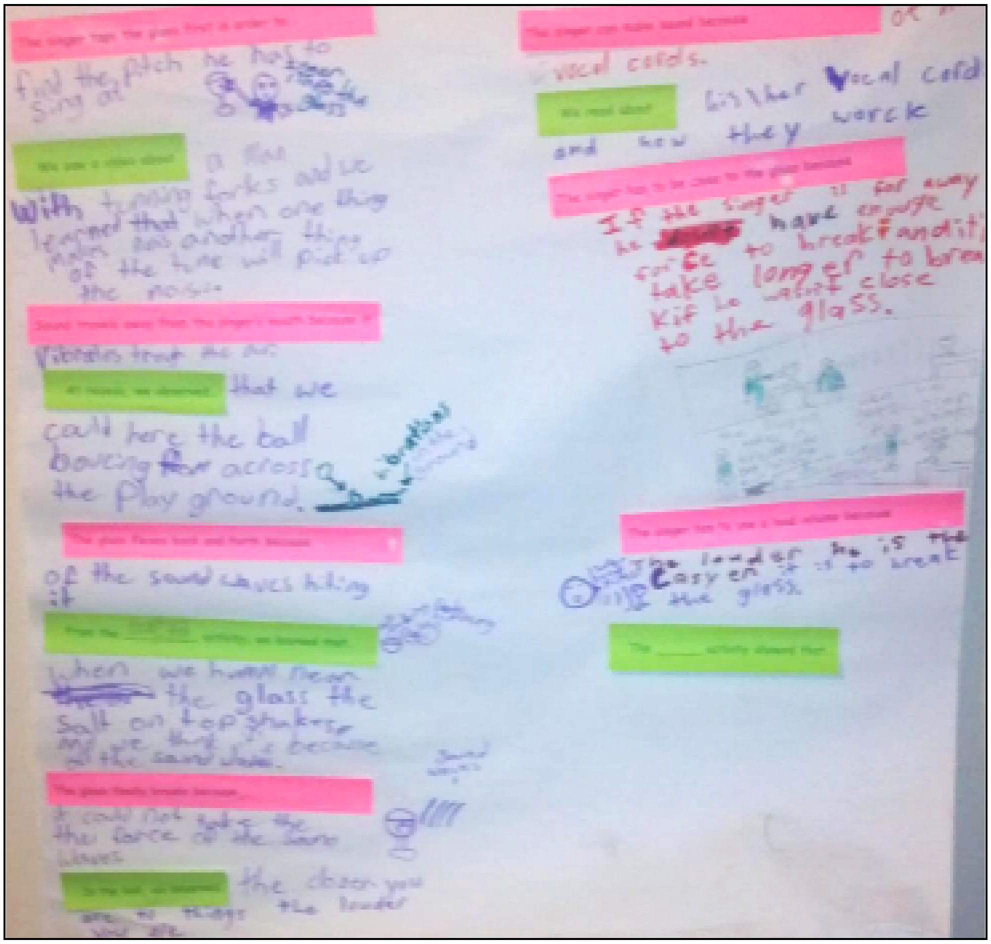

The Singer has to be close to the glass because the Volume and air molecules help's him with [illegible] breathing in he gets air and it helps him to Sing also how higth the volume gets That 'is why I think the glass needs to be close to his mouth. When went out side with a blow horn and whe She would press it the air molecules would Float ouround

Example C:
"The singer has to be close to the glass because the volume and air molecules help's him with breathing in he gets air and it helps him to sing also how higth the volume gets that is why I think the glass needs to be close to his mouth. When went out side with a blow horn and when she would press it the air molecules would float ouround [around]."

Feedback on Example C:
Some feedback for this student would be to recognize what is going well so far: This student makes a claim using ideas about volume and air molecules and attempts to connect to a source of evidence by describing an observation from an experiment. Then suggest some next steps:

- Clarify the claim. It is a little hard to follow the cause-effect relationship and how the author is pulling together ideas of volume, distance, and air molecules.
- Add evidence for the idea. How do you know about air molecules? How do you know that sound bumps molecules in the air in this chain reaction? Name the source and include some quotes or data to support the claim

Example D: Evidence-based explanations using the sentence starter strips



Example D:

"**The singer taps the glass first in order to…** *find the pitch he has to sing at.*
We saw a video about… *a man with tuning forks and we learned that when one thing makes another thing of the tune will pick up the noise.*

Sound travels away from the singer's mouth because it… *vibrates through the air.*
At recess, we observed… *that we could hear the ball bouncing from across the playground.*

The glass flexes back and forth because… *of the sound waves hitting it.*
From the ___hum bowl___ activity, we observed that… *when we hummed near the glass the salt on top shakes and we think it's because of the sound waves.*

The glass finally breaks because… *it could not take the force of the sound waves.*
In the hall, we observed… *the closer you are to things the louder you are.*

The singer can make sound because… *of his vocal cords.*
We read about… *his/her vocal cords and how they work.*

The singer has to be close to the glass because… *if the singer is far away he doesn't have enough force to break it and it takes longer to break if he wasn't close to the glass.*
The singer has to use a loud volume because… *the louder he is the easier it is to break the glass."*

Feedback on Example D:

This explanation shows attempts to pull together sets of claim + evidence to explain how the singer was able to shatter the glass. It includes small sketched models to illustrate key points to help the reader understand. A next step might be to work on adding explicit sentences to connect why that evidence supports the claim. Also, the students could make the evidence sentence more specific such as going beyond mentioning something students did by adding specific data patterns to help the reader trust the evidence.

Writing evidence-based explanations in science:

❏ I wrote my idea or claim clearly.
- Used specific words (not “it”)
- Used complete sentences
- Gave a real-world example of my idea
- Defined any science words I used with synonyms or phrases to help the reader know what I mean

❏ I explained how or why I think my claim is true, or when it is not true, using science concepts

❏ I supported my claim with evidence:
- data patterns
- quotes from text or video
- detailed personal experience

❏ I told the reader clearly and directly why or how this evidence supports my claim.

Writing evidence-based explanations in science:

❏ I wrote my idea or claim clearly.
- Used specific words (not “it”)
- Used complete sentences
- Gave a real-world example of my idea
- Defined any science words I used with synonyms or phrases to help the reader know what I mean

❏ I explained how or why I think my claim is true, or when it is not true, using science concepts

❏ I supported my claim with evidence:
- data patterns
- quotes from text or video
- detailed personal experience

❏ I told the reader clearly and directly why or how this evidence supports my claim.

Writing evidence-based explanations in science:

❏ I wrote my idea or claim clearly.
- Used specific words (not “it”)
- Used complete sentences
- Gave a real-world example of my idea
- Defined any science words I used with synonyms or phrases to help the reader know what I mean

❏ I explained how or why I think my claim is true, or when it is not true, using science concepts

❏ I supported my claim with evidence:
- data patterns
- quotes from text or video
- detailed personal experience

❏ I told the reader clearly and directly why or how this evidence supports my claim.

Writing evidence-based explanations in science:

❏ I wrote my idea or claim clearly.
- Used specific words (not “it”)
- Used complete sentences
- Gave a real-world example of my idea
- Defined any science words I used with synonyms or phrases to help the reader know what I mean

❏ I explained how or why I think my claim is true, or when it is not true, using science concepts

❏ I supported my claim with evidence:
- data patterns
- quotes from text or video
- detailed personal experience

❏ I told the reader clearly and directly why or how this evidence supports my claim.

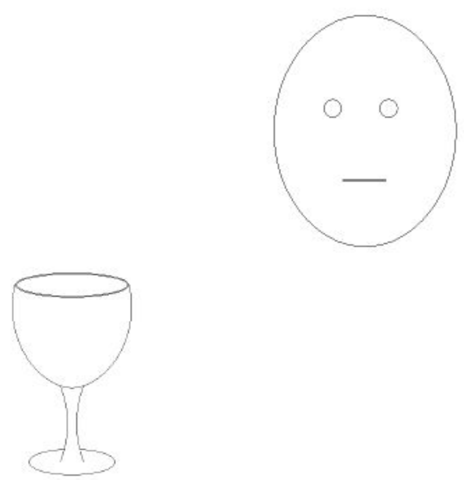
Name: ______________________________

Date: __________ Teacher: ______________

How did the singer shatter the glass with his voice?

Updating our Ideas

Before



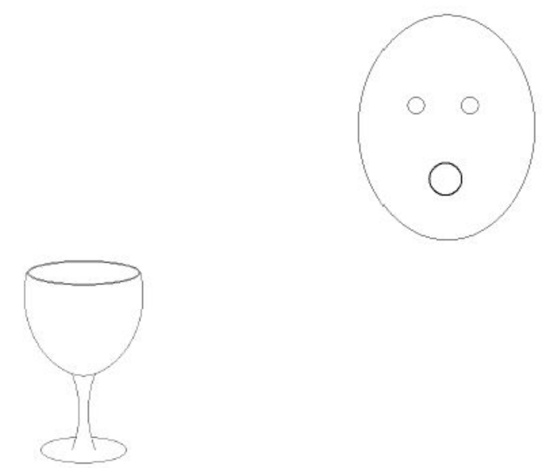
The singer flicks the glass because ____________________

My evidence for my idea is ____________________

Did you....?

- ❑ Draw sound using a symbol or representation
- ❑ Show how or where sound travels
- ❑ Show properties of sound like volume or pitch

During



The singer has to sing loudly because ____________________

My evidence for my idea is ____________________

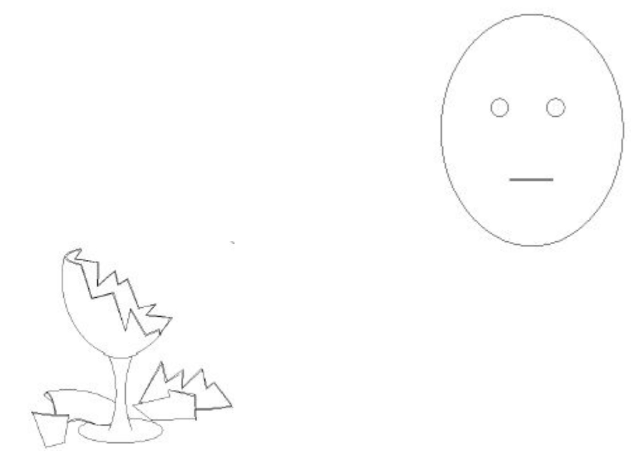
The singer has to be close to the glass because ____________________

I know this because ____________________

Did you....?

- ❑ Draw sound using a symbol or representation
- ❑ Show how or where sound travels
- ❑ Show properties of sound like volume or pitch

After



I think the glass eventually broke because ____________________

We could no longer detect the sound from the singer or the glass because ____________________

Did you....?

- ❑ Draw sound using a symbol or representation
- ❑ Show where sound travels when we can no longer hear it
- ❑ Show properties of sound like volume or pitch

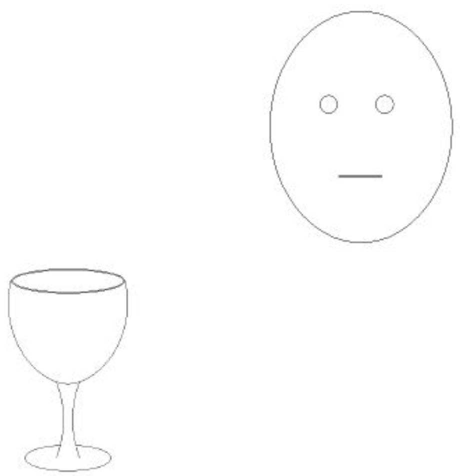
Name: ______________________________

Date: __________ Teacher: _______________

How did the singer shatter the glass with his voice?

Updating our Ideas

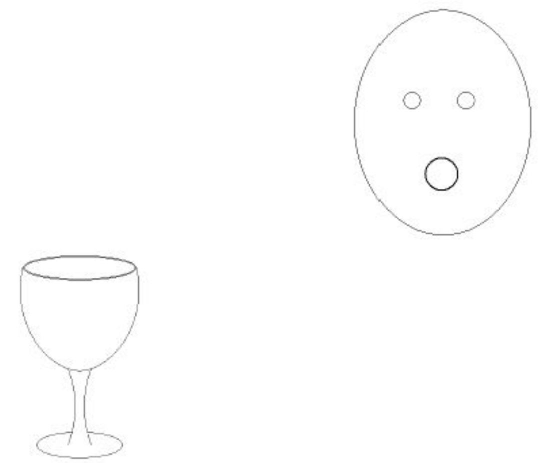
Before



Did you….?

- ❏ Draw sound using a symbol or representation
- ❏ Show how or where sound travels
- ❏ Show properties of sound like volume or pitch

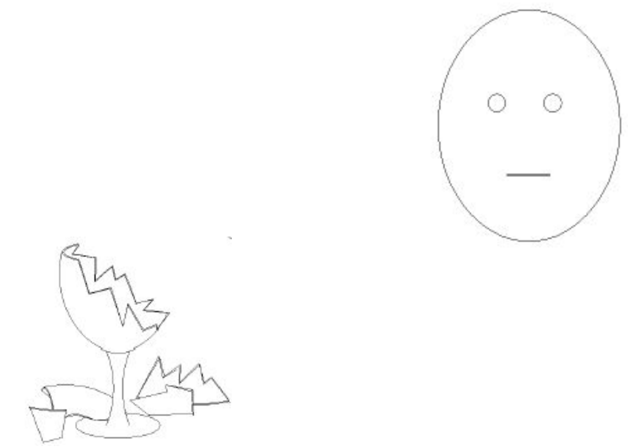
During



Did you….?

- ❏ Draw sound using a symbol or representation
- ❏ Show how or where sound travels
- ❏ Show properties of sound like volume or pitch

After



Did you….?

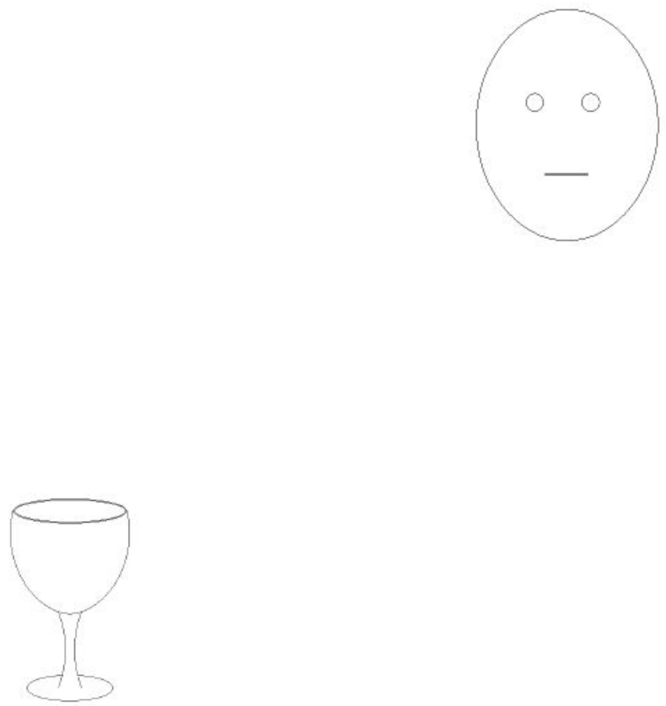
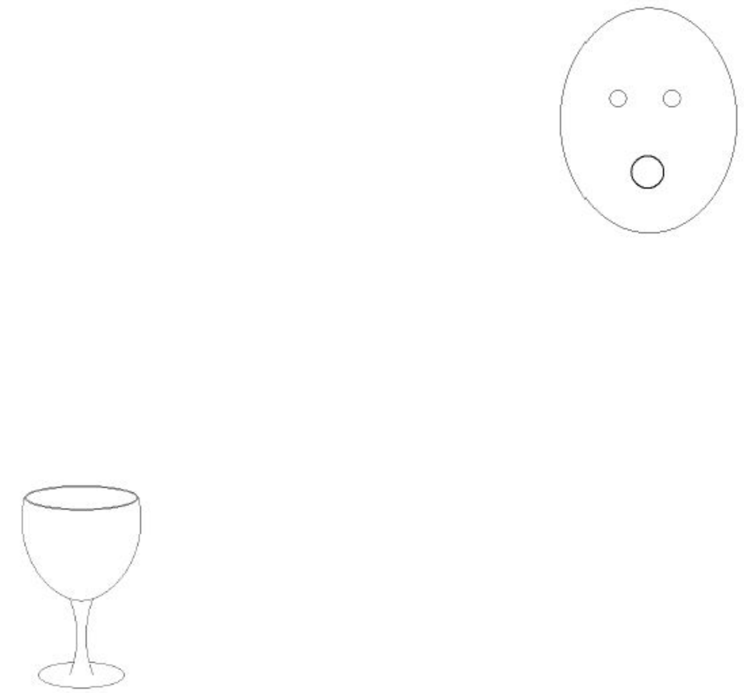
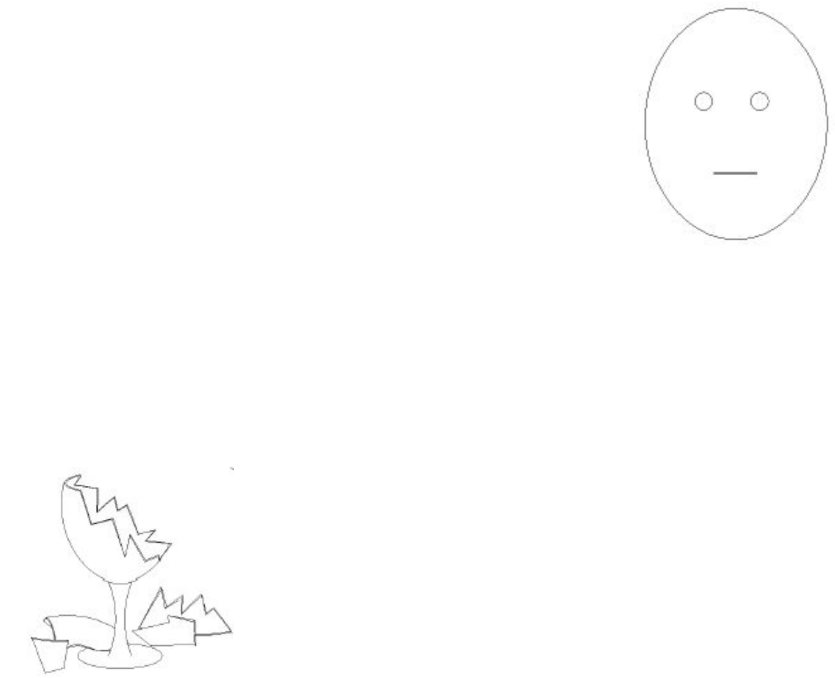
- ❏ Draw sound using a symbol or representation
- ❏ Show where sound travels when we can no longer hear it
- ❏ Show properties of sound like volume or pitch

Name: ______________________________

Date: __________ Teacher: _______________

How did the singer shatter the glass with his voice?

Updating our Ideas

Before	During	After
		

Sound Energy Unit Explanation Checklist

Did you show and write about…?

❏ How sound travels
Where does sound come from?
Where does sound go?

❏ How or why distance matters
What happens to sound as it goes farther from the source?
Why does the singer need to be close to the glass?

❏ Why volume is important
Where does he volume of a sound come from?
Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

❏ How sound travels
Where does sound come from?
Where does sound go?

❏ How or why distance matters
What happens to sound as it goes farther from the source?
Why does the singer need to be close to the glass?

❏ Why volume is important
Where does he volume of a sound come from?
Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

❏ How sound travels
Where does sound come from?
Where does sound go?

❏ How or why distance matters
What happens to sound as it goes farther from the source?
Why does the singer need to be close to the glass?

❏ Why volume is important
Where does he volume of a sound come from?
Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

❏ How sound travels
Where does sound come from?
Where does sound go?

❏ How or why distance matters
What happens to sound as it goes farther from the source?
Why does the singer need to be close to the glass?

❏ Why volume is important
Where does he volume of a sound come from?
Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

❏ How sound travels
Where does sound come from?
Where does sound go?

❏ How or why distance matters
What happens to sound as it goes farther from the source?
Why does the singer need to be close to the glass?

❏ Why volume is important
Where does he volume of a sound come from?
Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

❏ How sound travels
Where does sound come from?
Where does sound go?

❏ How or why distance matters
What happens to sound as it goes farther from the source?
Why does the singer need to be close to the glass?

❏ Why volume is important
Where does he volume of a sound come from?
Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

❏ How sound travels
Where does sound come from?
Where does sound go?

❏ How or why distance matters
What happens to sound as it goes farther from the source?
Why does the singer need to be close to the glass?

❏ Why volume is important
Where does he volume of a sound come from?
Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

❏ How sound travels
Where does sound come from?
Where does sound go?

❏ How or why distance matters
What happens to sound as it goes farther from the source?
Why does the singer need to be close to the glass?

❏ Why volume is important
Where does he volume of a sound come from?
Why does the singer have to be loud?

Sound Energy Unit Explanation Checklist

Did you show and write about…?

❏ How sound travels
Where does sound come from?
Where does sound go?

❏ How or why distance matters
What happens to sound as it goes farther from the source?
Why does the singer need to be close to the glass?

❏ Why volume is important
Where does he volume of a sound come from?
Why does the singer have to be loud?

TEACHER DIRECTIONS – CONSTRUCTING EXPLANATIONS

4th Grade Sound Energy

After students have engaged with several investigations, students have gathered evidence from observations about how sound energy is produced (or transformed from other energy), how volume is related to force, how sound energy travels through different materials, and what is going on inside us so we can make sounds. The lessons were chosen from the kit, and some lessons were added, specifically for how their conclusions about properties of sound energy can help explain how the singer was able to shatter the glass with his voice. Students are asked in this lesson to coordinate what they have learned from the different car investigations to apply it back to the singer scenario and explain why the singer was able to shatter the glass.

TIP #1: Divide the Task.

Writing a complete explanation of the singer phenomenon is a huge undertaking for individual students. Let students work in small groups (recommending no more than 3 per group). Talk about group-work norms – sharing talking and writing responsibilities. Check-in with groups on their explanations but also about group work norms.

TIP #2: Watch for vocabulary.

Students may still use a mix of science language and everyday language. If students use words like 'pitch' or 'volume' ask them to add in a sentence to their explanation saying more about what that means and particularly why that affects the singers' ability to break the glass so they don't hide behind science vocabulary.

TIP #3: Sentence Strips: Helpful or not?

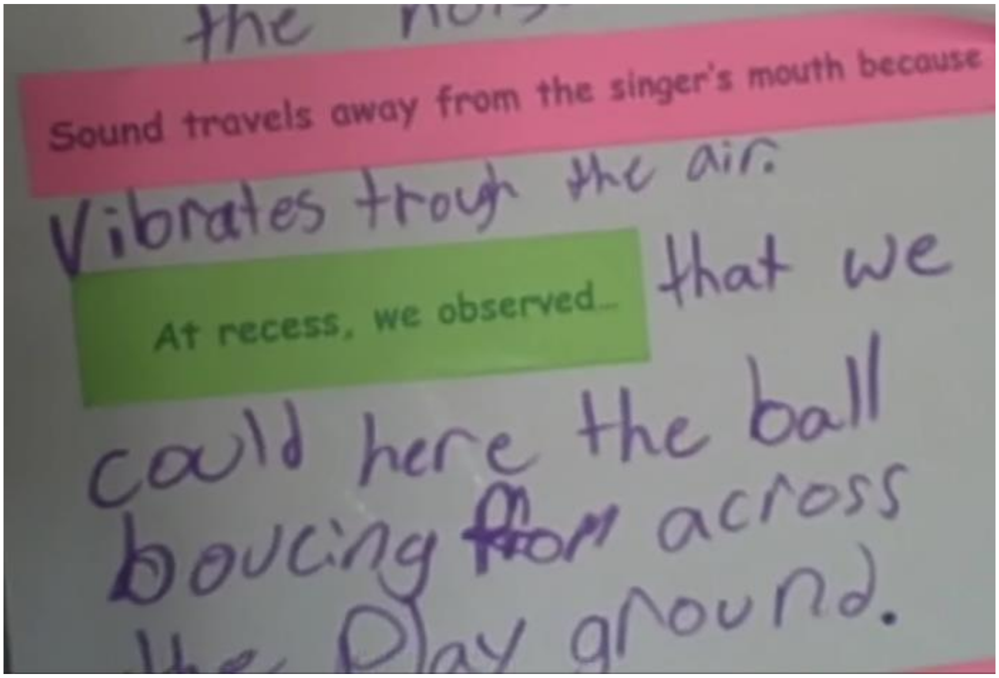
Students don't have to use the strips if they feel confused or confined by the phrasing. They can rewrite them in their own words and add in extra sentences about ideas that are important that may not be included. They are a guide to help with writing, but should not impede progress if students can be more productive without them.

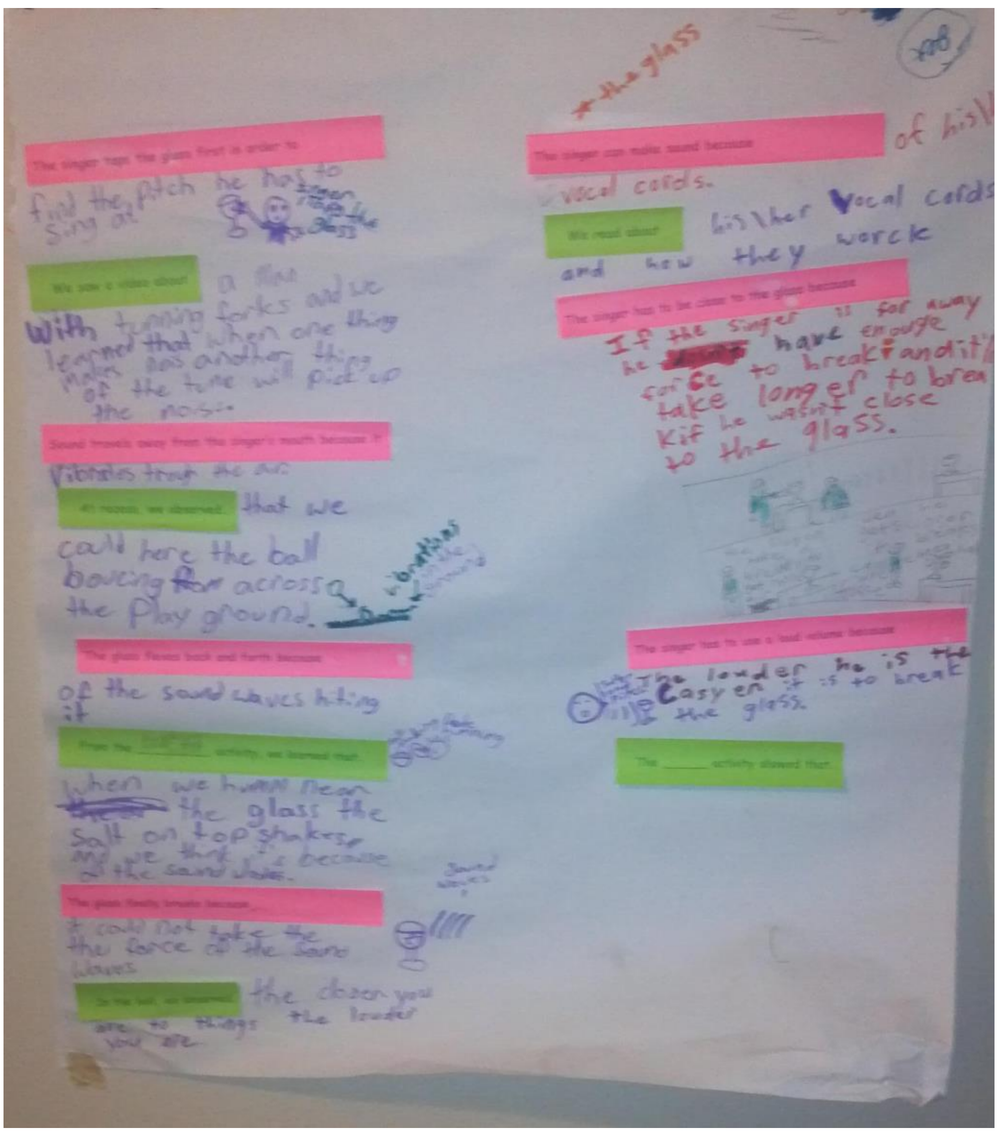
TIP #4: Remind Students to Look at the Summary Charts

After each activity, students provided input to create or add-on to a public chart about observations, new learning, and connections. There is a summary chart for each activity. Students can refer to those charts if they read an evidence sentence starter such as, "At recess, we observed…" and can go to the "Recess Activity" chart to remind themselves what evidence they collected during that activity.

Sound Energy Kit – Claim & Evidence Sentence Starter Activity for Constructing an Explanation

EXAMPLE OF STUDENT GROUP EXPLANATION Claim = Pink Evidence= Green





Sound Energy Kit – Claim & Evidence Sentence Starter Activity for Constructing an Explanation

CLAIMS – Copy on colored paper (different color than evidence). Cut apart, provide strips to groups or pairs of students. Students can also add their own sentences, too.

The singer taps the glass first in order to…

Sound travels away from the singers' mouth because…

The glass finally breaks because…

The singer can make sound because…

The singer has to be close to the glass because…

The singer has to use a loud volume because …

The glass flexes back and forth because…

Sound energy travels away from the singer's mouth because…

EVIDENCE – Copy on colored paper (different color than evidence). Cut apart, provide strips to groups or pairs of students. Students may use observations from one activity as evidence for two different claims.

We read about…

We saw a video about …

When we did partner whispers in the hall, we observed…

At recess, we observed…

When we knocked on the table…

The _________________ activity showed that …

From the ___________________ activity we learned that…

From the ___________________ activity we learned that…

OPTIONAL Reasoning *Copy on colored paper (different color than evidence). Cut apart, provide strips to groups or pairs of students. Students may use observations from one activity as evidence for two different claims.*

Based on this evidence, we know …

This evidence shows…

This evidence helps us better understand ________________ ______________________________________ because…

This result can be explained by…

Because of the data from this experiment, we know that…

This evidence supports our claim because…

This evidence supports our claim because…

This evidence supports our claim because…

Engineering Design Noisy Place Problems Part C

Purpose

In Part C, students craft a proposal describing the noisy place problem including data from Part A, justify their designed solution from Part B with evidence from unit activities, and propose evidence-based revisions to their solution prototype using data from Part B. This can be followed with an optional extension to present their solutions to the community and/or to iterate on the design and create a more long-lasting solution for the school community.

Learning Target

Focus questions

How well does your proposed solution address the noisy place problem?

Learning Target

I can support an argument with evidence from multiple sources to explain how or why our team's solution addresses the noisy place problem.

**You do not need to post a target statement. Instead, pose a question on the board.*

NGSS 3-D

SEP: Engaging in Argument from Evidence Support an argument with evidence, data, or a model

ETS1.B: Developing Possible Solutions At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

Influence of Science, Engineering, & Technology on Society & Natural World ***Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.***

Materials

For the class:

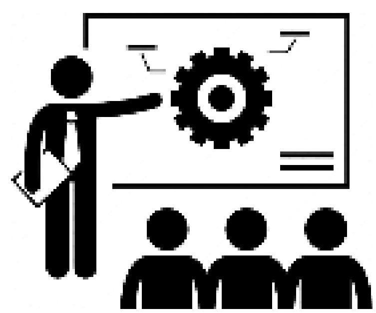
- Chart paper, markers, sticky notes

For each small group of students:

- 1 decibel meter
- 1 prototype built/tested in Part B

Per student:

- Science notebook and/or a copy of the Noisy Problems planning pages



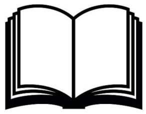
Lesson Step Summary

Days 1 - 4:

- *Optional: Revise and test a change to the prototype*
- Re-design and justify changes to the solution from Part B.
- Write an argument with evidence to explain how/why and to what degree the solution addressed the noise problem
- Provide feedback on written explanation based on criteria and data available as well as use of evidence and data.
- Incorporate feedback. Finalize justification of problem solution

Days 5+ *Optional: Rehearse and present to school community and/or create video of presentation and share. If possible, enact the solution, and further iterate to refine the design.*

Justifying & Arguing from Evidence - Multiple days

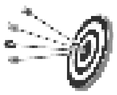


Silent Skim

1. **Framing: Reorient to noisy place problem and solution.**

Have students look at their notebooks and data to review their work: *What is the problem with noise? Where is it? Why is it a problem? What solution did you test? Did it meet the criteria? Did it help to solve the problem?*

OPTIONAL EXTENSION: Have a class discussion compare solutions here before going into the writing task. Based on the problems and solutions your student teams have tackled, you may have opportunities to compare and critique different solutions for the same problem. Alternatively, you may have teams that solved different problems in similar ways and could notice and discuss similarities and differences. Then students could alter their prototype and test the change (this adds days to the timeline).



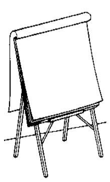
Purpose

Tell students that today they will start pulling the pieces together from the problem and initial data collection with the results from the prototype testing to write an evidence-based argument for why a particular solution works to solve the problem.

Turn-and-Talk

2. **Just-in-Time Instruction: What do community members or the principal need to know?**

Here's the scenario: What if we needed some money to purchase higher quality or nicer looking materials to solve our problem, such as proposing to the Principal, PTA, or other community members? We would need to argue for why it is important, why the problem exists, how our solution works, and what next steps could be.



Public Record

Assume your reader knows nothing about the problem or project. *What information do you think the reader would want to or need to know?* Think-pair-share. Generate a list on the board. Students can refer to this list as they are writing to make sure the reader or other community members have information to understand the problem and solution. Add additional criteria to the list: *Explain how you know what you know.*

Writing with Evidence

3. **Explore: Draft evidence-based argument for prototyped solution**

Have students get started outlining and drafting their evidence-based arguments. If helpful, use the notes organizer on page 8 of the Noisy Place packet. Students might also find the quarter sheet from lesson 10 helpful about how to write with evidence.

Share & Discuss

4. **Summarize: Checking in**

Have volunteers show part of their draft under the document camera. Focus around one claim + evidence paragraph or section. Have students use the "writing evidence-based explanation" checklist and the list on the board generated about what the reader needs to know to identify items the author has included and/or done well. Then students turn to a partner and decide on one area for feedback or improvement to suggest.

As time permits, have students do this kind of feedback routine for their explanation with a partner at their table group and then add or attend to feedback today or the next session and continue working on a written, evidence-based proposal.

Analyzing Student Work

How did students use **evidence** to support their argument that (1) their problem is a problem, and (2) their solution addresses or solves the problem?

Current performance & next steps	*Example*
1. Generalized claim about the problem with some description. No mention of evidence. ☐	*The hallways are too noisy after 4th grade recess. The 3rd grade teachers Mr. Brooke and Ms. Scott had to come out in the hallway to shush the 4th graders so the noise was loud enough to interrupt their teaching.*
2. Adds more detail about the problem. Names and/or describes the source of evidence. ☐	*The hallways are too noisy after 4th grade recess. The 3rd grade teachers Mr. Brooke and Ms. Scott often come out in the hallway to shush the 4th graders so the noise was loud enough to interrupt their teaching. We measured the volume of sound and it was 88 dB outside Mr. Brooke's class and 94 dB outside Ms. Scott's door near the stairwell.*
3. Explains the connection between the evidence and problem. ☐	*The hallways are too noisy after 4th grade recess. The 3rd grade teachers Mr. Brooke and Ms. Scott often come out in the hallway to shush the 4th graders so the noise was loud enough to interrupt their teaching. We measured the volume of sound and it was 88 dB outside Mr. Brooke's class and 94 dB outside Ms. Scott's door near the stairwell. The reading "Measuring Sound" says that these noise levels are louder than city traffic and that exposure to this sound for longer times over 30 mins to 1 hour could cause hearing damage. The 4th graders are only in the hall for a few minutes so there is not likely a chance for hearing damage but it does interrupt 3rd graders.*
4. Names and describes a possible solution. ☐	*The hallways are too noisy after 4th grade recess. The 3rd grade teachers Mr. Brooke and Ms. Scott often come out in the hallway to shush the 4th graders so the noise was loud enough to interrupt their teaching. We measured the volume of sound and it was 88 dB outside Mr. Brooke's class and 94 dB outside Ms. Scott's door near the stairwell. The reading "Measuring Sound" says that these noise levels are louder than city traffic and that exposure to this sound for longer times over 30 mins to 1 hour could cause hearing damage. The 4th graders are only in the hall for a few minutes so there is not likely a chance for hearing damage but it does interrupt 3rd graders. Because the 3rd grade classrooms are near the stairwell, particularly Ms. Scott's door, we think echoes from the stairwell with no carpet are traveling into the hallway. Therefore we want to add carpet to the floor and walls of the stairwell.*
5. Explains why the solution is likely to work using knowledge of science concepts, and data if available. ☐	[...] *Carpet is made of thousands of soft fibers that trap air molecules. Sound energy from laughing, talking, and footsteps vibrates molecules and bumps them into each other. The soft, flexible carpet fibers have air pockets that takes the energy from the bumping and moves it into all the fibers, trapping or moving the energy around so it won't echo back into the stairwell.*
6. Attempts to compare to other attempted solutions or suggest/justify improvements with evidence and/or knowledge of science concept.	[...] *We did not have carpet to test so we cut paper fringe and glued fringe and cotton balls on poster board and lined the walls in the stairwell near the 3rd grade hallway. We borrowed a carpet runner from the front office and put it on the floor. This solution decreased the stairwell sound measurement from around 90-100 dB without it to a MAX of 82 and a low to high of 62 to 82 when 4th graders came in from recess. We think real carpet will work better than our paper fringe and cotton balls on posters. When we did the "stop that sound" challenge the groups that used paper did not stop as much sound as the groups that used felt. Paper seems like a harder surface than fabric so it is more likely to bounce back the molecules bumping around the sound energy.*

Reflections & Notes