Fourth Grade Science

Waves - Sound

The following learning activities were backwards planned to facilitate the development of students' knowledge and skills for mastery of these NGSS Performance Expectations. Not all of the dimensions and CCSS are covered in the following activities and teachers are encouraged to address them where possible.

<table>
<tr><th colspan="3">4-PS4-1</th></tr>
<tr><td colspan="3">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.]</td></tr>
<tr><td colspan="3">The performance expectation above was developed using the following elements from the NRC document A Framework for K-12 Science Education:</td></tr>
<tr><td>Developing and Using Models
Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.
• Develop a model using an analogy, example, or abstract representation to describe a scientific principle. (4-PS4-1)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
• Science findings are based on recognizing patterns. (4-PS4-1)</td><td>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. (Note: This grade band endpoint was moved from K–2.) (4-PS4-1)
• Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (4-PS4-1)</td><td>Patterns
• Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena. (4-PS4-1)</td></tr>
<tr><td colspan="3">Connections to other DCIs in fourth grade:
4.PS3.A (4-PS4-1); 4.PS3.B (4-PS4-1)</td></tr>
</table>

Articulation of DCIs across grade-levels:
K.ETS1.A (4-PS4-3); **1.PS4.C** (4-PS4-3); **2.ETS1.B** (4-PS4-3); **2.ETS1.C** (4-PS4-3); **3.PS2.A** (4-PS4-3); **MS.PS4.A** (4-PS4-1); **MS.PS4.C** (4-PS4-3); **MS.ETS1.B** (4-PS4-3)

Common Core State Standards Connections:

ELA/Literacy -

SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. *(4-PS4-1)*

Mathematics -

MP.4 Model with mathematics. *(4-PS4-1)*

4.G.A.1 Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. *(4-PS4-1)*

	Hearing Sound	Telephone cups	Making Waves (Compression & transverse)	Making Waves (Frequency & Wavelength)
Student Experience	Students are provided the opportunity to hear sound from an instrument (live or a recording) to develop a model to demonstrate how they hear sound.	Students create telephone cups to explore how sound is transferred via a string (medium).	Students will use a slinky/phone cord to develop explores types of waves.	Students will generate standing waves using a slinky/phone cord to explore the relationship between frequency and wavelength.
T4T Material	Teacher may use materials from T4T to create an instrument that can produce various sounds.	Small Plastic cups, Lids, string	Possible cord?	Possible cord
Big Idea	Students develop a model to describe the transmission of sound from the source to the receiver.	Sound can travel through a medium without the medium being transferred (net movement).	Oscillation and energy transmission occurs through compression or transverse waves.	Frequency and wavelength are related. Frequency and wavelength are inversely proportional. As one increases the other decreases.
Connection to Culminating Activity	Introduction to the phenomenon of sound, driving question, and the development of their initial model.	A medium is required to transfer sound. Solids, liquids and gasses act as mediums that transfer sound without a net movement in the medium.	Sound waves are transmitted through compression waves.	Waves differ in their wavelength and frequency. Sound can have various wavelengths and frequencies.
Next Generation Science Standards	• Developing and using models. • SL.4.5 (CCSS English)	• **1-PS4-1.** • **1-PS4-4.** • **Cause and Effect (CCC)** • Patterns (CCC) • Plan & Carry out investigations(SEP) • Constructing Explanations & Designing Solutions (SEP) • MP.5	• MP.4 (CCSS Math) • 4.G.A.1 (CCSS Math) • Patterns (CCC) • PS4.A Wave Properties	• Patterns (CCC) • PS4.A Wave Properties

	Making Waves (Amplitude)	Sounds On Strings	Sounds in Tubes	Air Cannon
Student Experience	Students investigate how the amount of energy affects the wave form.	Students investigate how to create different sounds on vibrating strings.	Students investigate how to create different sounds in columns of air.	Students observe a pulse of air moving objects
T4T Material	Cords	String, materials to use as mass(apply tension)	Straws	Cardboard drum, rubber bands Pee cup lids, plastic
Big Idea	The amount of energy affects the height (amplitude) of a wave.	Length and tension affect sound pitch. Pitch is caused by changing frequencies & wavelengths.	Vibrations in air can produce sound.	Sound carries energy that can move through a medium to cause objects to move.
Connection to Culminating Activity	Amount of energy affects the amplitude of a wave. Loudness is perceived through the change in amplitude of a wave.	Vibrating strings can produce sounds. The length of the string and tension are two factors that can affect the pitch.	Air passing through a column can produce sound.	Sound passes through a medium as energy (wave) and causes the ear drum to move allowing sound to be heard.
Next Generation Science Standards	• 4-PS4-1 • Developing and using Models • Scientific knowledge is based on empirical evidence(SEP) • Patterns(CCC)	• 1-PS4-1 • Cause & Effect (CCC) • Plan & carry out investigations (SEP) • W.1.7 • Patterns(CCC)	• 1-PS4-1 • Cause & Effect (CCC) • Plan & carry out investigations (SEP) • W.1.7 • Patterns(CCC)	• 4-PS3-2 • Energy & matter (CCC) • Planning and Carrying out investigations(SEP) • Patterns(CCC)

Culminating Activity - Instrument Design & Model Construction	
Student Experience	Students design and construct an instrument that plays different sounds. Students develop their final model to demonstrate an explanation on how sound is heard from their musical instrument by other people and themselves.
T4T Material	Everything
Big Idea	Students design and engineer an instrument to demonstrate properties of sound. Students use their instrument to help model the transmission of sound.
Next Generation Science Standards	See above in NGSS Performance Expectation for 4-PS4 Waves and their applications in technologies for information transfer

Lesson Plans

Resources

https://www.youtube.com/watch?v=4S-MevRKGZs

Hearing Sound

Objective:

Observe phenomenon of sound and develop an initial model to explain how we hear sound.

Driving Question:

How do we hear sound?

Engage/Explore:

1. Teacher takes students outside to sit and explore what they hear.
    a. Predict
        i. Students predict what they will hear when they go outside.
    b. Observe
        i. "What do you hear?"
        ii. Students write down a detailed list of things they hear.

Explain:

1. Teacher leads a discussion with students
    a. "What did you hear?"
        i. Students can compare what they heard with a peer.
        ii. Students share out common things that they heard.
    b. Idea is to get students to focus on the idea that they are experiencing sound.

Elaborate

1. Teacher gathers students inside/outside and plays a few notes (sounds) from an instrument.
    a. Predict
        i. What will you hear when I play these notes?
        ii. Will they all sound the same?
    b. Observe
        i. Students listen to the sounds from the 3 notes.
        ii. Students record how they sound.

2. Teacher asks students to develop a model to explain how we hear these sounds.

a. Explain
    i. "How do you hear these sounds from the instrument?"
    ii. Students are given time to develop a model to explain how they hear sound.

Evaluate:

1. Teacher uses students initial models to gage prior knowledge and find misconceptions
2. **This assessment is informal and should not be assessed for accuracy of content.**

Telephone Cups

Objective:

Students use telephone cups to investigate how sound can transfer.

Engage:

1. Teacher leads students in the construction of telephone cups.
    a. Teacher may opt to construct the telephone cups beforehand.

Explore:

1. Students carry out an investigation to determine how the telephones are able to transmit sound.
    a. Predict
        i. How might these cups be used as a telephone?
        ii. What will happen to the sound if the string is not tight?
        iii. Can you hear a sound if the string is cut?
    b. Observe
        i. Students carry out experiments to test out their predictions
        ii. Students record their results.
    c. Explain
        i. How might these cups be used as a telephone?
        ii. What will happen to the sound if the string is not tight?
        iii. Can you hear a sound if the string is cut?

Explain

1. Teacher discusses with students their results of their experiment
    a. Is the string important in hearing sound? Explain.
    b. Is the string able to carry sound to the other person?

2. Teacher discusses the concept of a medium
    a. Solids, liquids, and gasses are mediums
    b. Teacher may also discuss the molecular interaction if desired.

Elaborate

1. Students are prompted to talk in pairs/small groups on what they have learned from the Cups.
    a. Teacher monitors discussion
2. Teacher pauses the discussion to ask questions
    a. "How are you able to hear your partner speaking?"
    b. "Where is the string?"
    c. "What is the medium that is carrying the sound?"
3. Students construct an explanation from the sequence to articulate that air is acting as a medium to carry sound from person to person.

Evaluate

1. Students modify their models to incorporate a medium

Making Waves – Compression & Transverse

Resources

https://www.youtube.com/watch?v=7cDAYFTXq3E

Objective

Investigate the two wave shapes – compression and transverse

Engage/Explore:

1. Teacher gives pairs of students a slinky and allows students to play with the slinky for a few minutes.
    a. Student Investigation – The stretched out slinky must be held to the surface at all times on either end.
    b. Predict
        i. Students predict the different ways they can shake the slinky without lifting it from the surface.

        ii. Students draw a sketch and explain how they would shake the slinky.
    c. Observe
        i. Teacher asks students to find as many ways as they can to "shake the slinky"
        ii. Students record observations by sketch and explanation.
    d. Explain
        i. Students will discover two distinct ways to shake the slinky (they do not know the names yet)
            1. Transverse
            2. Compression

Explain

1. Teacher gives a brief lesson on transverse and compression waves
    a. Sound is always transmitted as a compression wave.
    b. Light may be mentioned and that it is transmitted in a transverse wave form.
2. Students should take notes or record their learning.
3. It is encouraged that students take notes and teacher uses strategies to help students with vocabulary.
    a. Foldable, Concept Maps, Frayer Models, etc.

Elaborate/Evaluate:

1. Students act out "human waves" in small groups to demonstrate their knowledge of compression and transverse.
2. Teacher evaluates student's demonstrations for accuracy in depicting the waves.

Making Waves – Frequency & Wavelength

Resources

http://www.physicsclassroom.com/Class/waves/U10L2e.cfm

Objective:

Identify patterns in waves to interpret the relationship between frequency and wavelength

Engage/Explore:

1. Students will explore the changes in frequency and wavelength by shaking the slinky at different rates without removing it from the surface.

a. Predict
    i. "What will happen if you shake the slinky faster?"
    ii. What will happen if you shake the slinky slower?"
b. Observe
    i. Students draw pictures of the waves at different rates.
c. Explain
    i. Students make conclusion based on the patterns that they see in their drawings
    ii. Faster they shake the slinky closer the waves. (greater frequency/shorter waves)
    iii. Slower they shake the slinky further the waves (lower frequency/longer waves)

Explain:

1. Teacher introduces the terms frequency and wavelength as recognizable patterns in waves.
2. It is encouraged that students take notes and teacher uses strategies to help students with vocabulary.
    a. Foldable, Concept Maps, Frayer Models, etc.
3. Movement can be used to demonstrate relationship between wavelength and frequency.
    a. Students can clap or jump to demonstrate the inverse relationship (one goes up the other goes down).
4. Students can perform worksheet or other activities to measure wavelength of waves with a ruler.

Elaborate/Evaluate:

1. Will be conducted along with Making Waves – Amplitude.(see below)

Making Waves – Amplitude

Resources

https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_soundandlight/cub_soundandlight_lesson2_activity1.xml

http://www.physicsclassroom.com/Class/waves/u10l2c.cfm

Objective:

Investigate how energy affects waves and sound

Engage

1. Students sort a list of objects into categories – loud and soft
2. Ask students, "Why are some sounds loud and some sounds soft?"

Explore:

1. Students will use a slinky to determine how changing energy changes waves
    a. Predict
        i. "What will happen if you shake the slinky harder?"
        ii. "What will happen if you shake the slinky softer?"
    b. Observe
        i. Students draw pictures of the waves at different "strengths".
    c. Explain
        i. Students make conclusion based on the patterns that they see in their drawings
            1. What does shaking the slinky harder do?
            2. What does shaking the slinky softer do?

Explain:

1. Teacher introduces the concept of amplitude and discusses students results
    a. Shaking the slinky harder causes greater amplitude.
    b. Shaking the slinky softer causes less amplitude.
2. Amplitude measures the amount of energy associated with the wave. Waves with more energy have larger amplitudes.
3. Teacher can use hand clapping to demonstrate with students the concept of loudness and its relation to energy.
    a. Teacher can draw waves with different amplitudes on the boards and students clap to match big or small amplitude.

Elaborate

1. Outside voice vs. Inside voice
    a. Students use their knowledge of waves and amplitude to explain the difference between why they use their outside voice outside, and their inside voice inside.
        i. Distinguish energy changes
        ii. Loudness
    b. Concept Maps, Frayer Model, Drawings can be used by students to compare and contrast their two voices.
        i. Apply knowledge and visuals of waves

Evaluate

1. Simon Says – Waves!
    a. Students play Simon Says to demonstrate comprehension of wavelength, Frequency and Amplitude.
    b. Wavelength
        i. Spreading of feet or hands
        ii. Crunching up or stretching
    c. Frequency
        i. Jumping up and down
        ii. Clapping
        iii. Stomping
        iv. Drumming
    d. Amplitude – Amount of energy
        i. Clapping hands hard vs. soft
        ii. Jumping high vs. jumping low
2. Students can be given written or visual components where they have to provide reasoning why they selected a specific combination in Simon Says.

Sounds on Strings

Resources

http://www.physicsclassroom.com/mmedia/waves/gsl.cfm

http://www.physicsclassroom.com/class/sound/Lesson-5/Guitar-Strings

Objective:

Investigate ways that vibrating strings cause differences in sounds

Engage/Explore

1. Set up the initial investigation
    a. Class model for students to build or set up already done for students
    b. String ran across the table
    c. Clamp one end with a C-Clamp or tie it to the end of the table.
    d. The other end should hang over the table edge by pulley (with mass attached)
2. Students should explore
    a. Predict
        i. "What are two ways you can change the sound?"

b. Observe
    i. Experiment on different ways to change the sound
    ii. Students record their data
c. Explain
    i. "What did you change in order to produce different sounds?"
    ii. "What did this do to the string that allowed it to change sounds?"
        1. Students should be hinted to think in terms of wavelength and frequency.

3. The two methods that are used to change the sound include
    a. Changing mass – tension in the string
    b. Pushing down on the string – length of the string

Explain/Elaborate

1. Teacher leads a discussion on vibrating strings.
    a. Asks students
        ii. "What was happening to the string when different sounds were created?"
        iii. Students can explore different string instruments from the internet do recognize patterns
            1. "What patterns do you see in these instruments?"
            2. "How does this compare to the activity we did?"
    c. Vibrating string have different frequencies and wavelengths
        i. Changing the string changes the frequencies and gives different sounds
        ii. Simulation from phet.colorado.edu can be used to explore changes in frequency and its affect on sound
            1. http://phet.colorado.edu/en/simulation/sound

Evaluate

1. Students sketch a design of a stringed instrument
    a. Instrument must be able to play 3 different sounds
    b. Students write a brief explanation describing how this instrument can play 3 sounds.

Sound in Tubes

Resources

http://www.physicsclassroom.com/class/sound/Lesson-5/Open-End-Air-Columns

Objective

Investigate what affects sound in tubes.

Engage/Explore

1. Students are given straws to explore the way they can change the sound when blowing on the straws.
    a. Predict
        i. "What are two ways you can change the sound?"
    b. Observe
        i. Experiment on different ways to change the sound
        ii. Students record their data
    d. Explain
        i. "What did you change in order to produce different sounds?"
        ii. "What did this do to the string that allowed it to change sounds?"
            1. Students should be hinted to think in terms of wavelength and frequency.
2. The two things students can do to change sound in air
    a. Change the length of the straw
    b. Cover the end of the straws

Explain/Elaborate

1. Teacher leads a discussion on vibrating strings.
    a. Asks students
        i. "What changed in the straw when different sounds were created?"
        ii. Students can explore different wind instruments from the internet
            3. "What patterns do you see in these instruments?"
            4. "How does this compare to the activity we did?"
    b. Columns of air have different frequencies and wavelengths
        i. Changing column changes the frequencies and gives different sounds
        ii. Simulation from phet.colorado.edu can be used to explore changes in frequency and its affect on sound

http://phet.colorado.edu/en/simulation/sound

Evaluate

2. Students sketch a design of a simple wind instrument
    a. Instrument must be able to play 3 different sounds
    b. Students write a brief explanation describing how this instrument can play 3 sounds.

Air Cannon

Resources

http://www.physicscentral.com/experiment/physicsathome/cannon.cfm

https://www.youtube.com/watch?v=TV7jOEWVQHU

Objective

Develop an explanation on how sound causes objects to move.

Engage/Explore

1. Teacher shows students a giant air cannon
2. Teacher stacks a pyramid of cups a distance of 6 – 12 feet away.
3. Students are asked to perform an experiment led by the teacher.
    a. Predict
        i. Students make a prediction by answering the questions
            a. "What will happen when I fire the air cannon at the cups?"
            b. "How do you think this will happen?" Students ought to provide an explanation on what will occur to the cups when the air cannon is fired. This may be done as a visual and/or in writing.
    b. Observe
        i. Teacher fires the cannon at the cups. Volunteers from the students may be used at the discretion of the teacher. **Air cannons are safe and provide low risk to participants and audience members.**
        ii. Students should record data
            a. Sketches before/after
            b. Brief description of what they observed

c. Explain
    i. Students use their observation sheet to develop a detailed model to explain how the cups moved.
4. The teacher uses dry ice/fog machine to add a stronger visual.
5. Repeat the experimental process above with the use of the dry ice/fog
    i. A ring of smoke ought to be seen moving towards the cups.
6. Students should be given the opportunity to revise their initial model.

Explain

1. Teacher holds a discussion on sound waves.
    a. Sound waves travel through a medium to cause objects to move
    b. The air cannon demonstrate a pulse (like sound) traveling over a distance to cause movement in an object.
    c. The use of waves in water and the telephone activity from earlier may be used to reference examples of waves moving over a distance.

Elaborate/Evaluate

1. Students use concept mapping to compare and contrast the air cannon to sound waves.
    a. The air cannon is used to demonstrate how sound travels over distances to cause objects to move.
    b. There are subtle differences misconceptions that can be clarified through concept mapping
        i. The air cannon shows a ring of smoke/air moving over a distance
        ii. Sound no Matter moves (air does not have a net movement). Rather energy is carried over the distance.
        iii. The ring of smoke(matter) is analogous to energy(sound)
    c. Students may need additional support to make this subtle distinction or it may be left untouched. **Teacher ought to use discretion based on student needs.**
2. A revisit to the slinky activity can help students with this distinction
    a. Teacher ties a visible string to a location of the slinky.
    b. Teacher asks students
        i. "In what directions will the string move?"
        ii. "How will the energy move?"

c. The slinky is shaken to create a transverse wave.
    i. The energy should be seen moving across the slinky (through the matter)
    ii. The string should be seen oscillating up and down.
d. The energy (sound) is analogous to the ring.
e. The string is a demonstration that matter doesn't move in a wave. **Think of a boat on top of ocean waves.**

Culminating Activity – Instrument Design

Objective

Synthesize their knowledge and skills to explain the interactions of waves and matter to create a detailed explanation on how we hear the sound from their instrument.

Elaboration

1. Students design a musical instrument
    a. Drawings and sketches
        i. May be from the previous instrument lessons
        ii. May be a new design students create
2. Students' musical instrument
    a. Must produce at least 3 pitches/sounds
    b. Instrument is made from recycled materials
3. Students revise their initial model explaining how we hear the sound from their instrument.
    a. Types of Models that students can create (up to teacher discretion)
        i. 2-D diagrams, visuals
        ii. 3-D diagrams visuals – T4T materials
        iii. Analogies to demonstrate comprehension
    b. Models must include a description on how we hear sound starting from the source (instrument) to the receiver (ear).
    c. Models that extend beyond proficiency must include a description of how different sound waves are perceived (i.e. pitch is caused by different wavelength/frequencies)
4. Students present their work to the class in a way teacher selects
    a. Formal presentation
    b. Gallery walk
    c. School showcase
    d. Parent nights

Predict, Observe, Explain

Question	Prediction (hypothesis)	Observations	Explanations
The scientific questions that is asked by the teacher or may be proposed by the students.	Students' prediction in response to the questions. A great format to make predictions in science is in the form: **If… Then…**	Students' observations from experimentation. Data collection can be quantitative or qualitative. Data is presented in tables, drawings, lists, etc.	Students' make conclusions based on their observations. Explanations ought to be developed using Claims, Evidence, Reasoning (CER)

***Each experimental design will take on a different template. The template is affected by the type of data that is collected in the experiment. Teacher ought to modify and restructure the components of the generic template to fit each particular lesson.**

Generic POE + CER Template

Scientific Question:

Prediction

If . . . Then. . .

Observation

What do you observe?

Claim

What does your data show?

Evidence

What data is being used to make your claim?

Reasoning

How is your evidence connected to your claim?