Endeavor

STEM Teaching Certificate Project

The Science of Sound

Grades 4-6

STARBASE

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BIG IDEAS

Sound waves, frequencies, harmonies, ratios

EDUCATION STANDARDS

National Core for the Arts Standards: **Anchor Standard 5: Develop and refine artistic techniques and work for presentation.** **MU:Pr5.1.5b. Rehearse to refine technical accuracy and expressive qualities to address challenges, and show improvement over time.**
STARBASE Standards: **1.D.1.: The learner will utilize scientific principles to examine the world around us while investigating the relationship of science to society, technology, mathematics, and other disciplines.**

4.A.1.: The learner will solve problems using ratios expressed as a fraction, a decimal, or a percent.

MEASURABLE STUDENT LEARNING OBJECTIVES

Students will be able to identify different intervals.

Students will be able to translate ratios into fractions, decimals, or percentages.

STEM INTEGRATION

Science will be addressed with the discussion of vibrations through matter, how sound waves travel, and the different components of a sound wave.

Math will be addressed with the ratios between frequencies and converting them to fractions, decimals, and percentages.

Music will be addressed through the playing of instruments and experience of harmony.

This lesson will bring science, math, and music together with students learning from each subject separately, and then bringing them together to enhance their understanding. Science gives them a basic understanding of what sound is and how it travels. Music gives students an opportunity to experience the different frequencies and comprehend them as more than just numbers. Math allows students to have a better understanding of the relationship between frequencies and how our ears interpret that as harmony. The three subjects together provide students with a broader scope from which to learn. They will know the scientific basis of sound, experience it for themselves, and delve deeper into how frequencies relate to each other by working out the math.

NATURE OF STEM

The nature of STEM is interdisciplinary work and exploring concepts from multiple perspectives. Approaching ideas from a variety of vantage points deepens knowledge and provides the space for understanding to happen within a broader context. By using instruments to heighten comprehension and by computing the series of calculations, students will secure their learning of sound in its scientific sense. Sound is all around us

and understanding the math, and music behind the science makes this lesson more effective.

MATERIALS NEEDED

Projector/Board
Worksheets
Waveform Monitor
Boomwhackers
Calculators

ENGAGING CONTEXT/PHENOMENON

Tacoma Bridge Collapse – this is a video of what happened on November 7, 1940, when the winds were able to strike the bridge at its resonant frequency and the resulting sympathetic vibration caused enough movement that the bridge collapsed. A brief description of the event is available on the History channel's website. To extend this idea into an engineering challenge, consider this Practical Engineering video.

DATA INTEGRATION

Seeing Sound NASA Activity (Educator Demo Video)

Students will be collecting data surrounding the frequency of different pitches. They will fill out a chart that includes each note's frequency, musical pitch or tone, and a drawing of its image as displayed on the waveform monitor (when showing that of its tuning fork). This will allow students to understand sound in a myriad of ways.

Once the table is filled out, students will be led in a discussion to compare and contrast each sound.

TEACHER BACKGROUND KNOWLEDGE

Teachers should have a basic understanding of wavelengths and their components.They should be familiar with the Tacoma Narrows Bridge collapse.

Teachers should understand frequencies and know the ratios of musical octaves, fifths,

fourths, and thirds. They should be able to put those notes in the context of a musical scale (do and Do, do and sol, do and fa, do and mi). They also need to know how to instruct students in playing boomwhackers and what not to do, although they are quite versatile and not easily broken.

Teachers should understand the difference between fractions, decimals, and percentages, and should be able to define them in a few different ways.

DIFFERENTIATION OF INSTRUCTION

All information conveyed will be displayed on the board as well as communicated verbally so that students can process it both visually and auditorily.
Students will have the worksheet in front of them as well as it being displayed on the board so that the class can work as a whole while individuals can follow along at their own pace.
The boomwhackers are accessible for all students and can be held whichever way works best for them, using one or both hands. Additionally they can be struck on multiple surfaces and are audible with minimal force.
Students will have access to calculators for all mathematical equations.
STARBASE instructors, teachers, and aides will be available for any one-on-one support that is needed and for any students that are struggling and need assistance.

REAL-WORLD CONNECTIONS FOR STUDENTS

We hear sounds every day. Understanding how they work and how they interact with each other is something that students can continue to explore on their own or specifically in regards to music. There are apps that can identify frequencies so students can discover what pitch the sounds in their everyday life resonate at. It is an excellent opportunity to ponder what constitutes music and how easy it can be to create.

INTEGRATION POSSIBLE MISCONCEPTIONS

Students probably haven't thought about how sound travels at the molecular level or how the math behind it works. Some may be familiar with the musical understanding of pitches and their intervals, which may be confusing as they have their own names in music theory (thirds, fourths, fifths, octaves) which do not line up with the fractions of their frequencies (⅘, ¾, ⅔, ½, respectively).

LESSON PROCEDURE

5E	Details of 5E Lesson Implementation
Engage *Introduce the lesson with an anchoring phenomenon. Facilitate student questions, discussion, etc. as appropriate. Learn about what students already know and want to know.*	**Procedure:** ● Watch *Tacoma Bridge Collapse* ● Ask students what they think caused the collapse ○ Wind matched the bridge's resonant frequency causing sympathetic vibrations ● Ask students if they've heard of something similar (vibrations interacting with an object) ○ Opera singer shattering wine glass ○ Feeling the bass when listening to music ● Employ think-pair-share technique **Modifications** ● Prepared questions displayed during discussion **Standards Addressed** ● STARBASE 1.D.1.: The learner will utilize scientific principles to examine the world around us while investigating the relationship of science to society, technology, mathematics, and other disciplines. **Formative/Summative Assessments** ● Student participation ● Student responses **Resources** ● Tacoma Bridge Collapse ● History Channel description of event

Explain *Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts.*	**Procedure:** ● Teacher informs students: ○ Sound is a type of energy. ○ Sound waves travel through matter (solids, liquids, or gasses). Molecules vibrate due to the energy of the sound source. This causes a cycle of compression (molecules moving closer together as a result of vibration) and rarefaction (when they return to their original position) as the sound wave passes through the molecular structure of the medium. ○ Sound waves have four main parts: ■ Wavelength: the distance of one cycle (crest to crest or trough to trough) ■ Period: the time of one cycle (crest to crest or trough to trough) ■ Amplitude: the height of the crest or the trough, the degree of loudness (measured in decibels [dB]) ■ Frequency: the number of cycles per second, interpreted by the brain as pitch (measured in hertz [Hz]) ○ The faster the vibrations/the greater the frequency, the higher the pitch; the slower the vibrations/the smaller the frequency, the lower the pitch ○ Human hearing range is about 16 Hz to 16 kHz **Modifications** ● Information displayed as it is presented verbally **Standards Addressed** ● STARBASE 1.D.1.: The learner will utilize scientific principles to examine the world around us while investigating the relationship of science to society, technology, mathematics, and other disciplines.

Explore *Plan for students to engage in hands-on activities that are designed to facilitate conceptual change.*	**Procedure:** ● Seeing Sound Waveform Monitor ○ Invite a few volunteers to speak, sing, or make sound into the apparatus ○ Strike tuning forks for C (both octaves), E, F, G ○ Have students draw what they see for each of those five notes in "Waveform Image" column ○ Lead students in compare/contrast discussion ● Boomwhacker Play ○ Instruct students on proper playing technique ○ Allow students a brief time to play freely ○ Have students play note by note (in same octave/same size) ○ Highlight certain intervals: ■ Octave - C and c ■ Fifth - C and G ■ Fourth - C and F ■ Third - C and E **Modifications** ● Refer to boomwhackers by note/name and color **Standards Addressed** ● NCAS Anchor Standard 5: Develop and refine artistic techniques and work for presentation. ● 1.D.1.: The learner will utilize scientific principles to examine the world around us while investigating the relationship of science to society, technology, mathematics, and other disciplines. **Formative/Summative Assessments** ● Student participation/performance ● Worksheet "Waveform Image" column completed **Resources** ● NASA Seeing Sound Activity

Elaborate *Provide applications of concepts and opportunities to challenge and deep ideas; build on or extend understanding and skills.*	**Procedure:** ● Identify frequencies of C, E, F, G, and C (upper octave) ○ Have students play the selected note ○ Have students fill in their "Frequency" column ● Identify the ratio of the four highlighted intervals ○ Have students play again ○ Have students fill in the ratios ● Have students do the math to work out the ratios ○ The higher note/smaller frequency is the numerator, the lower note/larger frequency is the denominator ○ Simplify the fraction ■ Octave (C to c) is ½ ■ Fifth (C to G) is ⅔ ■ Fourth (C to F) is ¾ ■ Fifth (C to E) is ⅘ ○ Convert the fraction to decimal ○ Convert the decimal to percentage **Modifications** ● Refer to boomwhackers by note/name and color ● Provide calculators ● Complete the first problem together, leading the class through the problem and prompting steps with volunteers providing the answers **Standards Addressed** ● NCAS Anchor Standard 5: Develop and refine artistic techniques and work for presentation. ● 4.A.1.: The learner will solve problems using ratios expressed as a fraction, a decimal, or a percent. **Formative/Summative Assessments** ● Worksheet filled out with math completed correctly **Resources**

	• **Frequency Guide** ○ **The typical boomwhacker set will include C4-C5**

Evaluate
 	
Assess students knowledge, skills and abilities.
	Procedure:
	
	• **Have students, in groups, complete the work for another set of notes**
	  ○ **Provide students with two notes and frequencies**
	  ○ **Students do the math to determine ratios, simplified fractions, decimals, and percentages then identify which interval they received**
	  ○ **Options**
	  ■ **Thirds: F and A, G and B**
	  ■ **Fourths: D and G, E and A, G and C**
	  ■ **Fifths: D and A, E and B, F and C, G and D**
	
	Modifications
	
	• **Provide calculators**
	
	Standards Addressed:
	
	• **1.D.1.: The learner will utilize scientific principles to examine the world around us while investigating the relationship of science to society, technology, mathematics, and other disciplines.**
	• **NCAS Anchor Standard 5: Develop and refine artistic techniques and work for presentation.**
	• **4.A.1.: The learner will solve problems using ratios expressed as a fraction, a decimal, or a percent.**
	
	Formative/Summative Assessments
	
	• **Groups present to the class and explain their findings**