Integrated STEM Unit Planner

Grade 1 Science
Design a Sound-Generating Device

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PreK-12STEM
Community Training & Assistance Center (CTAC)
Tracy Unified School District

About the Integrated STEM Units

The integrated STEM units are a product of the partnership between Community Training and Assistance Center (CTAC) and Tracy Unified School District (TUSD) in California, funded in part through the Education Innovation and Research (EIR) program of the U.S. Department of Education in 2018. Teacher leaders came together to develop innovative units that align to STEM standards for student learning—namely the Next Generation Science Standards (NGSS) for California Public Schools, the Computer Science Content Standards derived from the national K-12 Computer Science Framework, and the California Common Core State Standards.

Each integrated unit brings together the following:

- an engineering design challenge
- one or more computational artifacts
- core science and math content
- language building opportunities
- engagement supports

Students in each grade level, pre-kindergarten through twelve, engage with the unit for about one or two months as part of their required coursework. The units are integrated and self-contained as a means to provide all students with equitable STEM experiences.

About the Partners

Community Training and Assistance Center (CTAC) is a national not-for-profit organization with a demonstrated record of success in the fields of education and community development. Tracy Unified School District, located in California's Central Valley, serves approximately 15,000 students. Fifty leading teachers from the district contributed to the development of the units. Computer Science integrations resulted with support from the San Joaquin County Office of Education and Bootstrap of Brown University.

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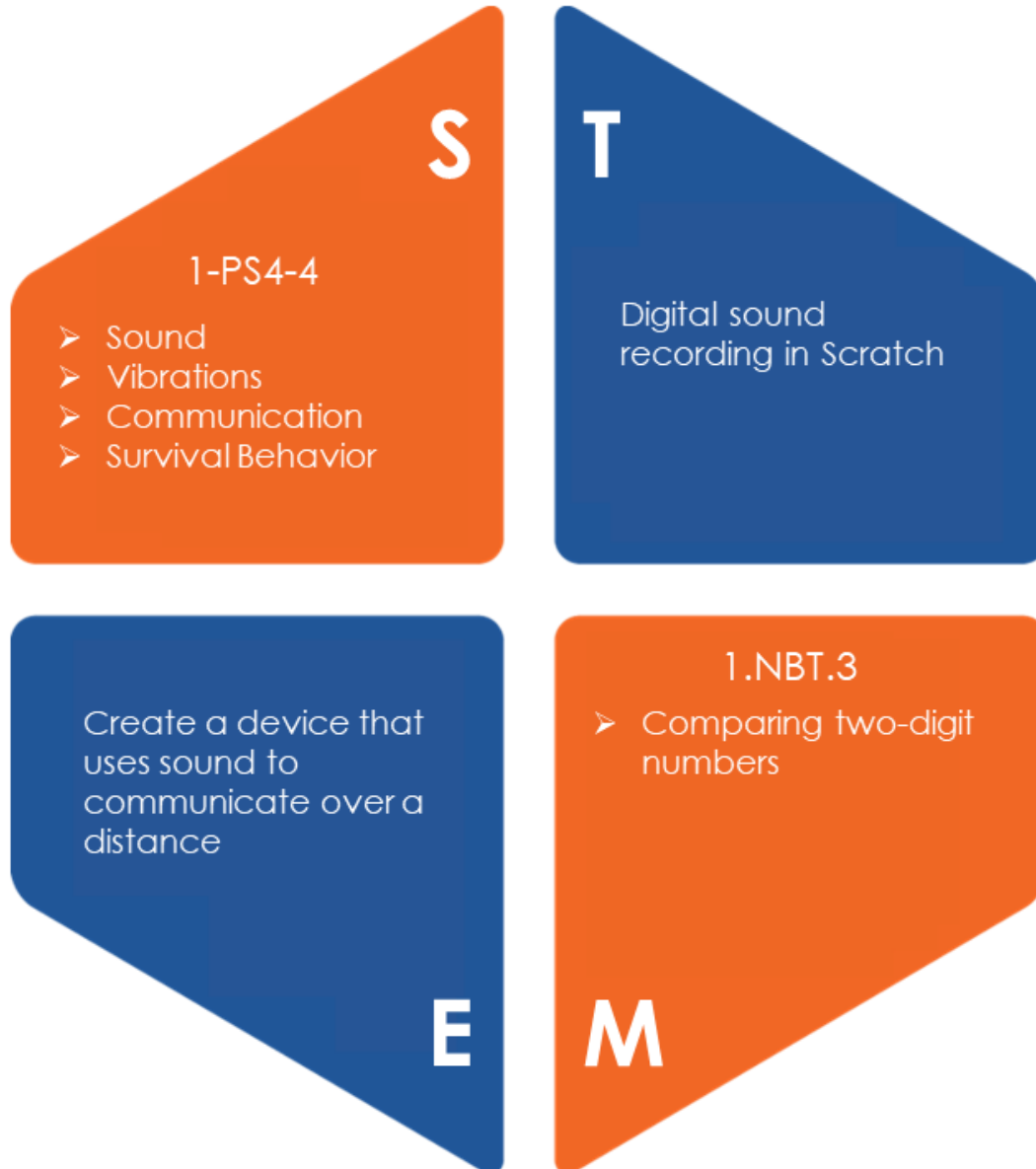
Contents

Unit Emblem

S 1-PS4-4
- Sound
- Vibrations
- Communication
- Survival Behavior

T Digital sound recording in Scratch

E Create a device that uses sound to communicate over a distance

M 1.NBT.3
- Comparing two-digit numbers

Focal Standard

1-PS4-4 Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.* [Clarification Statement: Examples of devices could include a light source to send signals, paper cup and string "telephones," and a pattern of drum beats.] [*Assessment Boundary: Assessment does not include technological details for how communication devices work*.]

Overview

Sequence 1: Teachers engage students with an anchoring phenomenon by playing a video of crickets chirping (CedarFox, 2008)[i] (https://bit.ly/3aNsRCE). Students will discuss what they hear and ask questions about why and how the cricket makes these noises.

Students will be introduced to the driving essential question: How do young animals communicate with their parents to survive? The emphasis will be on sound and how sound is an effective method for transmitting signals over long distances.

This will lead to the design challenge when students will be asked to create a tool that can transmit a message through sound to indicate hunger and danger. Students will begin consideration of this task by **ask**ing the following questions: Why do offspring communicate with their parents? How can we use the behavior or actions of an animal to communicate using sound?

Sequence 2: Students will learn more about sound and vibrations that create sound. Students will sketch out ideas for their tool and **plan** their tool using the materials provided.

Sequence 3: Students will gather the necessary materials and **create** their sound device. Students will learn about sound as a form of communication.

Sequence 4: Students will learn how animals use sound to communicate important messages such as hunger, danger, food nearby and other survival needs. Students will **test** the effectiveness of their tool and use the decibel meter to measure the loudness of the tones they create. They will use data from these trials to determine which method produced the loudest sound.

Sequence 5: Students will reflect on the data collected in the tests and work to **improve** their sound warning device.

Integrated Unit Storyline

Students ask questions like Why do offspring communicate with their parents? How can we use the behaviour or actions of an animal to communicate using sound?

MATHEMATICS
Comparing two-digit numbers

Ask

Students sketch out their vision and share ideas to come to consensus

ENGINEERING

Plan

Students create their tool

Create

Students collect data on how well their tool works

Test

Students refine their tool based on data

Improve

Approximate Duration: 6 weeks

SCIENCE

Sound

People also use a variety of devices to communicate (send and receive information) over long distances

Vibrations

Sound can make matter vibrate, and vibrating matter can make sound.

Communication

People also use a variety of devices to communicate (send and receive information) over long distances

Survival Behaviors

Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive.
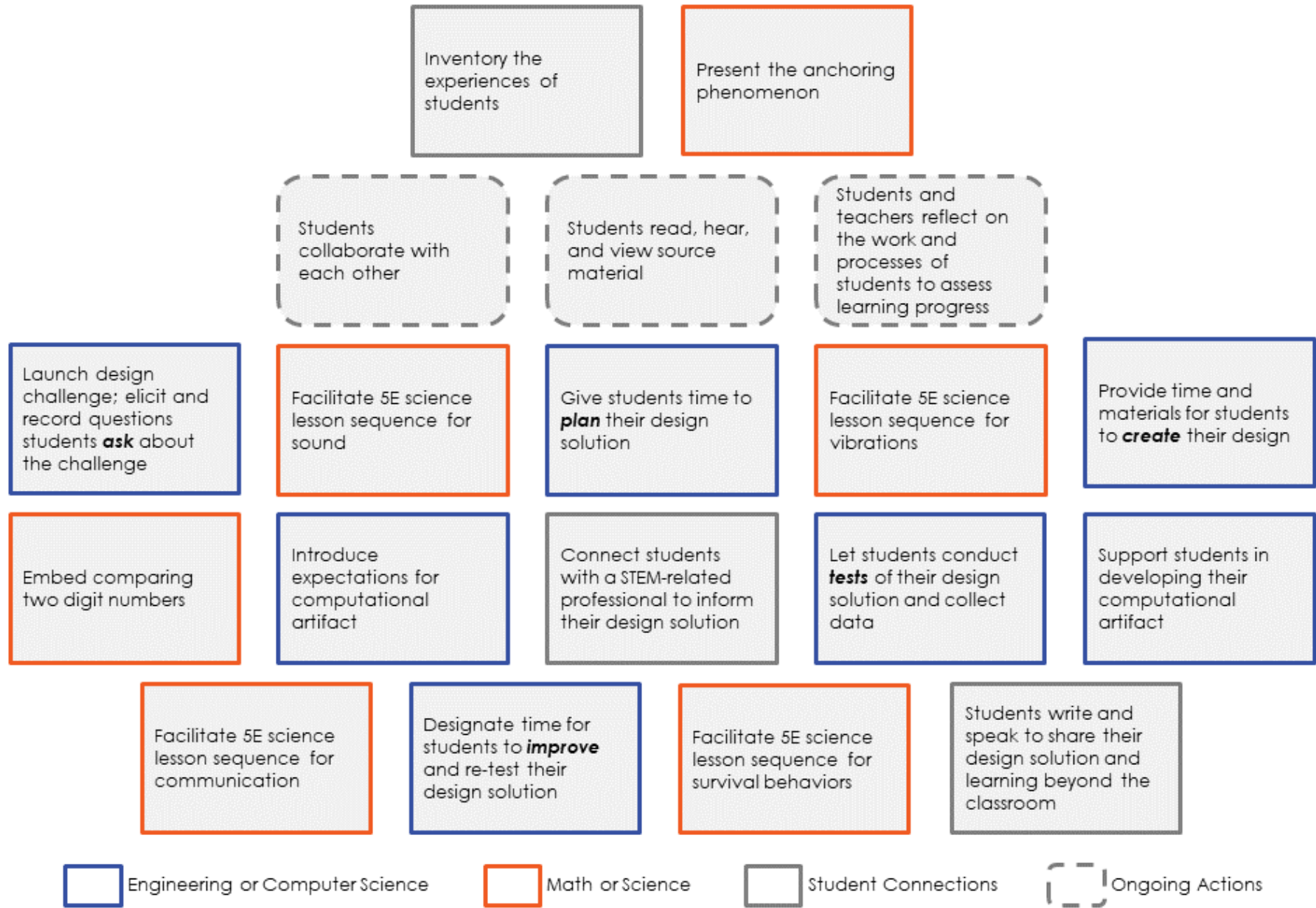
COMPUTATIONAL ARTIFACT
Digital sound recording in Scratch

Integrated Unit Wayfinder

Inventory the experiences of students

Present the anchoring phenomenon

Students collaborate with each other

Students read, hear, and view source material

Students and teachers reflect on the work and processes of students to assess learning progress

Launch design challenge; elicit and record questions students **ask** about the challenge

Facilitate 5E science lesson sequence for sound

Give students time to **plan** their design solution

Facilitate 5E science lesson sequence for vibrations

Provide time and materials for students to **create** their design

Embed comparing two digit numbers

Introduce expectations for computational artifact

Connect students with a STEM-related professional to inform their design solution

Let students conduct **tests** of their design solution and collect data

Support students in developing their computational artifact

Facilitate 5E science lesson sequence for communication

Designate time for students to **improve** and re-test their design solution

Facilitate 5E science lesson sequence for survival behaviors

Students write and speak to share their design solution and learning beyond the classroom

Engineering or Computer Science   Math or Science   Student Connections   Ongoing Actions

STEM Dive

Engineering

Design Challenge: Create a device to use sound to communicate over a distance.

Type of Engineering: Acoustical Engineer

The Engineering Design Process (EDP) and Engineering Standards

EDP Step	Standard and Grade Band End Points from the *Framework*
Ask *Why do offspring communicate with their parents? How can we use the behavior or actions of an animal to communicate using sound?*	**K-2-ETS1-1.** Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. • A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1) • Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) • Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)
Plan *Students sketch out their vision and share ideas to come to consensus.*	**K-2-ETS1-2.** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. • Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2)
Create *Students create their tool.*	
Test *Students collect data on how well their tool works.*	**K-2-ETS1-3.** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs. • Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)
Improve *Students refine the tool based on data.*	

Computer Science (Technology)

Computer Science Integrations

Description of Student Engagement

Students create digital recording of a sound for hunger and danger in Scratch.

Computational Artifact

Definition: Anything created by a human using a computational thinking process and a computing device. A computational artifact can be, but is not limited to, a program, image, audio, video, presentation, or web page file. (Source: College Board, 2016)

- Sound recording in Scratch indicating hunger or danger

Hardware

Definition: The physical components that make up a computing system, computer, or computing device. (Source: MDESE, 2016)

- Computer with microphone and speaker

Software (includes programs, applications, websites, etc.)

Definition: Programs that run on a computing system, computer, or other computing device. (Source: k12cs.org)

- Scratch

Standards

- **K-2.DA.8** Collect and present data in various visual formats.
- **K-2.AP.10** Model Daily Processes by creating and following algorithms to complete tasks.
- **K-2.AP.14** Develop plans that describe a programs sequence of events, goals, and expected outcomes.

Science

Focal Standard

1-PS4-4 Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.* [Clarification Statement: Examples of devices could include a light source to send signals, paper cup and string "telephones," and a pattern of drum beats.] [*Assessment Boundary: Assessment does not include technological details for how communication devices work.*]

Related Content Standards

1-LS1-2 Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive. [Clarification Statement: Examples of patterns of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).]

1-PS4-1 Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. [Clarification Statement: Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.]

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

Anchoring Phenomenon

Teachers engage students with an anchoring phenomenon by playing a video of crickets chirping (https://bit.ly/3aNsRCE).

Content Outline

Below is a content outline for the science content in this unit. It includes the key concepts within the unit along with an approximate number of days it would take to facilitate a sufficient amount of student learning experiences. For each key concept, key learnings appear, which come from the grade band endpoints in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (source: https://www.nextgenscience.org/framework-k-12-science-education). The storyline begins with an anchoring phenomenon.

Key Concept	Key Learnings	# of Days
Sound	• People also use a variety of devices to communicate (send and receive information) over long distances. (1-PS4-4)	10

Key Concept	Key Learnings	# of Days
Vibrations	• Sound can make matter vibrate, and vibrating matter can make sound. (1-PS4-1)	10
Communication	• People also use a variety of devices to communicate (send and receive information) over long distances. (1-PS4-4)	5
Survival Behavior	• Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive. (1-LS1-2)	5

Science and Engineering Practices	Crosscutting Concepts
1. Asking questions and defining problems **2. Developing and using models** **3. Planning and carrying out investigations** 4. Analyzing and interpreting data 5. Using mathematics and computational thinking **6. Constructing explanations and designing solutions** 7. Engaging in argument from evidence **8. Obtaining, evaluating, and communicating information**	**1. Patterns** **2. Cause and effect** 3. Scale, proportion, and quantity 4. Systems and system models 5. Energy and matter 6. Structure and function 7. Stability and change

Note. Bolded items are called out specifically in the standards cluster for this unit.

Mathematics

Description of Student Engagement

Students will compare the sound levels of their warning sounds using the decibel meter and be able to interpret which tones were louder based on the readings. (Students ignore the decimals on the device and focus on only the whole numbers they see on the device.)

Standards for Mathematical Content

1.NBT.3 Compare two two-digit numbers based on meanings of the tens and ones digits, recording the results of comparisons with the symbols >, =, and <.

Standards for Mathematical Practice

MP.1 Make sense of problems and persevere in solving them.

MP.2 Reason abstractly and quantitatively.

MP.3 Construct viable arguments and critique the reasoning of others.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

MP.6 Attend to precision.

MP.7 Look for and make use of structure.

MP.8 Look for and express regularity in repeated reasoning.

Note. Bolded items are emphasized in this unit.

English Language Arts and Development

Reading Standard: Integration of Knowledge and Ideas

RI.1.8 Identify the reasons an author gives to support points in a text.

Writing Standard: Text Types and Purposes

W.1.2 Write informative/explanatory texts in which they name a topic, supply some facts about the topic, and provide some sense of closure.

W.1.3 Write narratives in which they recount two or more appropriately sequenced events, include some details regarding what happened, use temporal words to signal event order and provide some sense of closure.

Writing Standard: Research to Build and Present Knowledge

W.1.7 Participate in shared research and writing projects (e.g., explore a number of "howto" books on a given topic and use them to write a sequence of instructions).

Speaking and Listening Standard: Comprehension and Collaboration

SL.1.1 Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.

- **SL.1.1.a** Follow agreed-upon rules for discussions (e.g., listening to others with care, speaking one at a time) about the topics and texts under discussion.
- **SL.1.1.b** Build upon others' talk in conversations by responding to the comments of others through multiple exchanges.
- **SL.1.1.c** Ask questions to clear up any confusion about the topics and texts under discussion.

Language: Conventions of Standard English

L.1.1 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

- **L.1.1.f** Use frequently occurring adjectives.
- **L1.1.j** Produce and expand complete simple and compound declarative, interrogative, imperative, and exclamatory sentences in response to prompts.

L.1.2 Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

- **L.1.2.d** Use conventional spelling for words with common spelling patterns and for frequently occurring irregular words.
- **L.1.2.e** Spell untaught words phonetically, drawing on phonemic awareness and spelling conventions.

Unit Vocabulary

The following terms reflect the core vocabulary students should understand and use in this unit.

- **adult**: An adult is something or someone that is fully grown and developed. (Source: https://www.merriam-webster.com/dictionary/adult)

- **behavior**: Behavior is the way a person or animal acts or behaves. (Source: https://www.merriam-webster.com/dictionary/behavior)

- **external structure**: External parts are the visible components of a plant or animal. This would include things like the stem, leaves, and flowers of plants and the arms, legs, eyes, and ears of animals.

- **function**: A function is the special purpose or activity for which a thing exists or is used. (Source: https://www.merriam-webster.com/dictionary/function)

- **offspring**: Offspring are the young of a person, animal, or plant. (Source: https://www.merriam-webster.com/dictionary/offspring)

- **parent**: A parent is an animal or plant that produces offspring. (Source: https://www.merriam-webster.com/dictionary/parent)

- **pattern**: A pattern is the regular and repeated way in which something is done [or something appears]. (Source: https://www.merriam-webster.com/dictionary/pattern)

- **predator**: A predator is an animal that lives mostly by killing and eating other animals. (Source: https://www.merriam-webster.com/dictionary/predator)

- **prey**: Prey is an animal that is hunted or killed by another animal for food. (Source: https://www.merriam-webster.com/dictionary/prey)

- **signal**: A signal is something (such as a sound, a movement of part of the body, or an object) that gives information about something or that tells someone to do something. (Source: https://www.merriam-webster.com/dictionary/signal)

- **similar**: Similar means having qualities in common. (Source: https://www.merriam-webster.com/dictionary/similar)

- **solution**: A solution is something that solves a problem. (Source: https://www.merriam-webster.com/dictionary/solution)

- **sound**: A sound is a sensation that is experienced through the sense of hearing. (Source: https://www.merriam-webster.com/dictionary/sound)

- **sound wave**: A sound wave is a wave that is produced when a sound is made and is responsible for carrying the sound to the ear. (Source: https://www.merriam-webster.com/dictionary/sound%20wave)

- **tool**: A tool is an instrument (as a saw, file, knife, or wrench) used or worked by hand or machine to perform a task. (Source: https://www.merriam-webster.com/dictionary/tool)

- **tuning fork**: A tuning fork is a metal instrument that gives a fixed tone when struck and is useful for tuning musical instruments. (Source: https://www.merriam-webster.com/dictionary/tuning%20fork)

- **vibrate**: To vibrate is to move or cause to move back and forth or from side to side very quickly. (Source: https://www.merriam-webster.com/dictionary/vibrate)

- **vocalize**: To vocalize means to express (something) by speaking words. (Source: https://www.merriam-webster.com/dictionary/vocalize)

- **warning**: A warning is something (such as an action or a statement) that tells someone about possible danger or trouble. (Source: https://www.merriam-webster.com/dictionary/warning)

Assessment Tools

Student Experience Inventory

Teachers can use the following prompts with students prior to the beginning of the unit or early in the unit in order to learn about students' experiences that relate to the unit. Teachers can make informed instructional decisions based on this learning, enabling tailored opportunities for students to make their own meaning.

Student Prompts

1. When you want to tell somebody something, what things (devices) do you use to tell them?

2. What baby animals have you seen? How are they like their parents? How are they different from their parents?

3. What movies or books about animals have you seen or read?

4. What kinds of sounds do you like to hear?

Aligned Learnings

1. Responses to this item provide insight into students' experiences with communication methods. 1-PS4-4

2. Responses to this item provides insight into students' experiences with the characteristics of offspring. 1-LS3-1

3. Responses to this item provide insight into what animal behaviors students have observed. Note that fictional movies or books about animals may portray some inaccurate behaviors. 1-LS1-2

4. Responses to this item provide insight into what sounds students have experienced, which may be good sounds to use for vibration and sound experiences in class. 1-PS4-1

Student Self-Assessment of Engineering

Improve:
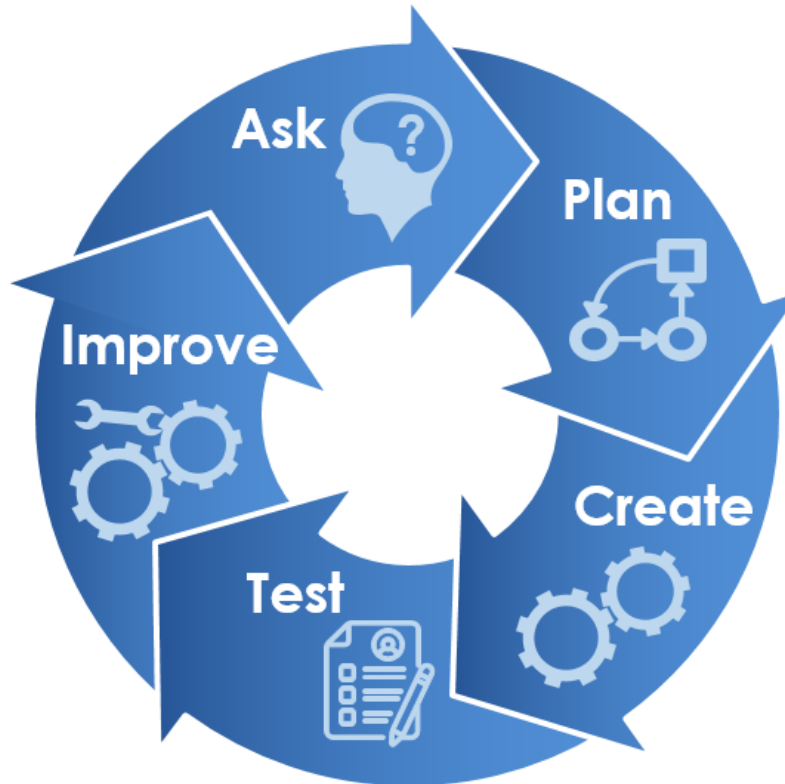Here is what would make my design better and why...

Ask:
Here is what I am wondering about before I plan my design...

Plan:
Here are my design ideas for the project...

Test:
Here are the data I collected...

Create:
Here is what I think about what I made compared to what I planned, and here is what I think will happen when I test it...

I am doing the work of a acoustical engineer.

One-Point Design Challenge Rubric

Criteria serve as a primary reference point throughout the engineering design process. Teachers use the criteria **to communicate expectations** and **to guide students**. With teacher guidance, students use the criteria to inform and reflect on their work.

Approaches Expectations *Notes on how to improve the project*	Meets Expectations *Criteria indicating success*	Exceeds Expectations *Notes on how project goes beyond expectations*
	Engineering Students participate in the 5-part engineering design process, use data, and make thoughtful improvements to their design. (K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3)	
	Computer Science Students use Scratch to record a sound indicating hunger or danger. (K-2.DA.8, K-2.AP.10, K-2.AP.14)	
	Collaboration Students contribute and support others with honesty and kindness (SL.1.1)	
	Communication Students speak and write about their ideas clearly using accurate vocabulary (W.1.1, W.1.2; W.1.3). Students will share thoughts, read, and listen to learn from others. (SL.1.1)	
	Science Students will be able to build a device that communicates sound over a distance and understand how patterns of behavior of parents and offspring contribute to their survival. (1-PS4-4; 1-PS4-1; 1-LS1-2)	

Engagement

 Community and Career Connections

During the unit, students engage with STEM professionals who can inform students' work at some point during the engineering design process. The interaction with STEM professionals serves a few purposes:

- Expose students to STEM as it applies in various careers
- Enrich student learning through collaborating with STEM professionals
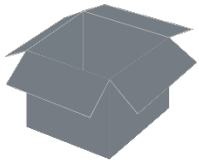- Help students see themselves doing the actual work of STEM

Below are a few potential STEM-related professionals that align to one of California's 15 industry sectors for Career and Technical Education:

- **Zookeeper** (Hospitality, Tourism, and Recreation)
- **Veterinarian** (Health Science and Medical Technology)
- **Stage Production Sound Crew Member** (Arts, Media, and Entertainment)

The interactive experience will ideally be co-constructed by the teacher and professional. In coordinating with the professional, a few questions appear below that can be used to guide the planning and live interaction with students:

- **Zookeeper** (Hospitality, Tourism, and Recreation)
  - What animals do you work with on a daily basis?
  - How have you seen them communicate with one another? What method do they use to communicate?
  - Can you tell the difference between chattering, warning, hunger, or other kinds of messages these animals share?
  - Do young animals seem to know how to communicate from birth or can you tell if they are taught by their parents?

- **Veterinarian** (Health Science and Medical Technology)
  - What kinds of sounds of behaviors do animals use to communicate with each other?
  - What kinds of bodily signals (beyond what the owners tell you) do you look for to help decide what is bothering an animal that comes to you for care?
  - How important is animal communication to their survival? Can you give an example?
  - We understand that there are some gorillas and chimpanzees that researchers believe have learned to use some kind of sign language (Koko, gorilla, American Sign Language; Washoe, chimpanzee, American Sign Language). Do you think they really know what they are "saying"? Why or why not?

- **Stage Production Sound Crew Member** (Arts, Media, and Entertainment)
  - What are the important factors to consider when making sure that the voices of the actors or the presenters can be heard throughout the auditorium?
  - How do sound waves interact with the room people are in? Does it make a difference if there are more or less people in the room?
  - How does a microphone work to help us hear better?
  - What is the worst kind of place to try to get sound to carry?

Materials List

The items in the materials list below reflect total quantities for a class of 32 students, allowing for 8 groups of 4 students.

Permanent Equipment (classroom totals):

- ☐ 8 decibel meters (1 per group)
- ☐ 16 tuning forks, 8 each of 2 different tones (2 per group)

Consumable Equipment (classroom totals):

- ☐ 320 (3 oz.) paper cups
- ☐ 64 yards of string
- ☐ 160 rubber bands
- ☐ 1 lb. bag of rice (about 4 teaspoons per group)
- ☐ 1 roll of wax paper (about 4 square feet per group)
- ☐ 5 sheets of sandpaper (super-fine grit)
- ☐ 32 rolls of clear tape

Consumable Equipment (from home or site as available):

- ☐ Empty water bottles
- ☐ Paper towel rolls
- ☐ Cereal/tissues boxes
- ☐ Cardboard boxes of various sizes
- ☐ Plastic bottle caps
- ☐ Pencils

Distance Learning Modifications

In distance learning, the design challenge will be conducted by students individually at home. Student collaboration will need to occur remotely with a modified materials list.

Modified Materials List (student totals):

- ☐ 10 paper cups (size)
- ☐ 2 yards of string
- ☐ 5 rubber bands
- ☐ 1 teaspoon of rice
- ☐ 1 square foot of wax paper
- ☐ 1/6 of a sheet of sand paper

Endnotes

[i] CedarFox. (2008, August 31). *Crickets chirping.* YouTube. https://www.youtube.com/watch?v=CQFEY9RIRJA