Overall Rating: E

Example of High-Quality NGSS Design

EQuIP Rubric for Science Unit
Peer Review Panel Feedback

Unit Name: How Can We Sense So Many Different Sounds From A Distance?
Grade Level: Middle School

Category I. NGSS 3D Design

	Criteria	Evidence of Quality? None	Inadequate	Adequate	Extensive
Unit Criteria	A. Explaining Phenomena/Designing Solutions: Making sense of phenomena and/or designing solutions to a problem drive student learning.				X
	B. Three Dimensions: Builds understanding of multiple grade-appropriate elements of the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) *that are deliberately selected to aid student sense-making of phenomena and/or designing of solutions*.				X
	i. *Provides opportunities to develop and use specific elements of the SEP(s).*				*X*
	ii. *Provides opportunities to develop and use specific elements of the DCI(s).*				*X*
	iii. *Provides opportunities to develop and use specific elements of the CCC(s).*				*X*
	C. Integrating the Three Dimensions: Student sense-making of phenomena and/or designing of solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs.				X
	D. Unit Coherence: Lessons fit together to target a set of performance expectations.				X
	E. Multiple Science Domains: *When appropriate*, links are made across the science domains of life science, physical science and Earth and space science.				X
	F. Math and ELA: Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects.				X

Category I Rating: 3

At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C

Criterion A.

Specific evidence from materials and review team consensus reasoning:

Student sense-making is clearly driven by student-created questions related to the anchoring phenomenon and subsequent lesson-level phenomena. The goal of making sense of the anchoring phenomenon is clearly a driving factor of the entire unit, as students often revisit the driving question board (DQB) to add additional questions and determine what questions have been answered as they create content knowledge around the topic. The provided teacher guide is an invaluable tool that helps the teacher carefully frame the experience to guide the students to wonder and ask their own questions, keeping the anchoring phenomenon at the core of student sense-making.

Students directly experience anchoring phenomena at the beginning of each bend to support extended student sense-making through student developed questions. Each phenomenon is experienced by students as directly as possible. Students either manipulate the phenomenon through classroom experiences or experience the phenomenon through video, creating a shared common experience for all students in the class. Students make sense of the phenomena

	through observation, journaling, class discussion or "scientist circle," recording on the Incremental Model Tracker, and reaching consensus toward the end of each lesson. Examples of anchoring phenomena include: • **Bend 1:** A cone and needle dragged over the surface of a plastic disc seem to create voices and music; • **Bend 2:** Observing sound from a car shaking the windows of a store front; • **Bend 3:** An otoscope video of an eardrum examining the structures in the ear canal; and • **Bend 4:** Reflection on previous phenomena, (optional) deconstruction of a speaker, video of speaker cone being deformed. In addition to anchoring phenomena at the beginning of each bend, the lessons that follow include lesson-level phenomena to support student sense-making of questions developed from the anchoring phenomena or from the previous lesson. Some examples include: • A record playing a long song and noticing patterns in the movement of the needle **(Lesson 2);** • Various musical instruments and slow-motion video of instruments **(Lesson 3);** • Motion detector senses the movement at the end of a clamped wooden stick **(Lesson 6);** • Harp strings of different lengths create different sounds **(Lesson 7);** • A cellphone can be heard even when in a plastic bag; the mass doesn't change **(lesson 9);** • A computer simulation collects data on particle packing **(Lesson 12);** • Ears and a sound detection app provide evidence of how volume and frequency change as distance from sound source changes (**Lesson 16);** • Quiet noises sound louder with a long tube **(Lesson 17); and** • A homemade speaker **(Lesson 22).**
	Suggestions for improvement: The reviewers have no suggestions at this time. We feel that this storyline is an excellent example of how the role of phenomena can be used to drive student sense-making.
Criterion B.	**Specific evidence from materials and review team consensus reasoning:** **<u>Science and Engineering Practices</u>** Many opportunities exist for students to develop and use specific grade appropriate elements of the Science and Engineering Practices (SEPs). Students actively use science practices to make progress on their explanation toward the phenomenon. It is important to note that every lesson includes student active engagement in the practices. The Lesson Performance Expectations (LPE) specify which SEP is being emphasized in each lesson: the bolded blue font shows the SEP, and the regular blue font quotes the relevant element from Appendix F. We identified several elements of SEPs that are in the background of student learning, and focused here on elements that are explicitly used by students. Some examples linked to specific elements are below: **Asking Questions and Defining Problems** • When students explore anchoring phenomenon at the beginning of each bend **(Lesson 1, Lesson 8, Lesson 14, Lesson 21)** and develop and, later, refine their driving question board, they are *asking questions that arise from careful observation of phenomena, models or unexpected results, to clarify and/or seek additional information*.

- Based on the intentional choice of phenomena by the unit designer, student questions developed in relation to phenomena *require sufficient and appropriate empirical evidence to answer,* and *can be investigated within the scope of the classroom…with available resources.*

Developing and Using Models

- During **Lesson 1**, students create an initial model to explain how we hear so many different voices and sounds from across the room when we spin the record. Throughout the unit, students reflect on their initial model and how it could be modified based on new evidence. The **Incremental Model Tracker** used throughout the unit (**Lesson 1-13)** provides students with a scaffold to help them record gathered evidence that could change their initial model. In doing this, students are:
    - *Developing and/or revising a model to show the relationships among variables, including those that are not observable but predict observable phenome;*
    - *Developing and/or using a model to predict and/or describe phenomena; and*
    - *Developing a model to describe unobservable mechanisms.*

Using Mathematics and Computational Thinking

- When students use motion detectors and computer simulations to collect data about the movement of objects **(Lesson 5, 6, 12**), they are *using digital tools to analyze very large data sets for patterns and trends.*
- When students completed the investigation in **Lesson 15** that modeled energy transfer to an object, they collected data, calculated averages, and compared their results to look for patterns. In doing this they *applied mathematical concepts and/or processes to scientific questions*.

Planning and Carrying Out Investigations

- When students plan investigations where they design an experiment to test how air is moved from the sound source to the sensor (**Lesson 9, 10),** determine whether greater amplitude/frequency creates more damage (**Lesson 15)**, and test how to make the sound louder using paper tubes/cones **(Lesson 17)** they are *planning an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim*

Engaging in Argument from Evidence

- The teacher prompts students to engage in evidence-based argumentation routinely throughout the unit. When students decide which competing claim is correct, based on evidence, through oral argument **(Lesson 7)**, they are *constructing, using, and/or presenting oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.*

Obtaining, Evaluating, and Communicating Information

When students summarize and take notes on the informational text of how the human ear detects sound using a graphic organizer **(Lesson 14)** they are *gathering, reading, and synthesizing information from multiple appropriate sources and assessing the credibility, accuracy, and possible bias of each publication and method used, and describing how they are supported or not supported by evidence.*

Disciplinary Core Ideas
This unit is designed to explicitly focus on the middle school elements related to PS4.A, PS4.B PS4.C, PS3.B, LS1.D and PS2.B.

Lessons 1-4 mainly focus on Disciplinary Core Ideas (DCI) elements within the elementary grade band rather than middle school, but these lessons are essential foundations for how sound travels, and students need to understand the mechanisms of what causes sound in order to answer their driving question. It is also essential to helping students form a joint mission and sustain the need to answer their developed questions. We feel that, though these are not grade-level elements, they are essential to be included for the coherence of the storyline.

Some examples are included below:

- When students explore a cell phone ringing in a closed system (Ziploc bag) and a vacuum **(Lessons 9, 10)** they are figuring out that *a sound waves needs a medium through which it is transmitted* **(PS4.A**);
- When students use a motion sensor to observe patterns of a vibrating wooden stick **(Lesson 5)** they are figuring out that *a simple wave has a repeating pattern with a specific wavelength, frequency and amplitude* **(PS4.A);**
- In **Lesson 23**, when students develop a model for how sounds are sampled, stored, and played back using analog and digital methods, they are figuring out that *digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information* **(PS4.C);**
- Throughout the unit, students uncover that *when the motion energy of an object changes, there is inevitably some other change in energy at the same time* **(PS3.B).** Whenever students investigate the movement of an object (like an instrument) and the sound it then makes or movement in the air, **(Lesson 1, 3, 7, 8, 9, 11, 12, 15, 18)** they are developing their understanding of this element
- When students explore the structure of the inside of the ear in **Lesson 14**, along with a video of a deafening sound, students are developing an understanding that *each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the rain, resulting in immediate behaviors* **(LS1.D); and**
- Students explore **PS2.B**, *electric and magnetic forces can be attractive or repulsive and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects* when they create their own speaker out of wire, magnets, and a cup/plate in **Lesson 22**.

Cross Cutting Concepts
Students build understandings of grade-appropriate elements of the Crosscutting Concepts (CCCs) throughout the unit. The unit is designed to explicitly build on the following:

Patterns

- Students make extensive use of patterns throughout the unit to ask questions, construct explanations, and argue from evidence;
- When students explore patterns in sounds **(Lesson 6),** vibrations **(Lesson 7)**, and particles **(Lesson 12)**, they are developing an understanding that *macroscopic patterns are related to the nature of microscopic and atomic-level structure*; and

- When students analyze graphs using motion detectors to distinguish the difference between amplitude and frequency **(Lesson 5, 6),** they are developing an understanding that *graphs and charts can be used to identify patterns in data.*

Cause and Effect:

- Throughout the unit, students continuously explore how *cause-and-effect relationships may be used to predict phenomena in natural or designed systems*. The nature of the unit is to explore what causes us to sense so many sounds from a distance, and therefore student questions throughout the unit often address the cause of the phenomena being explored.

Structure and Function:

- Students develop an understanding that *structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used* when they:
  - Explore the structure of a record on a microscopic level **(Lesson 2)**;
  - Read about how insects use body structures to produce sounds **(Lesson 3)**;
  - Explore how different lengths of string (harp and guitar) affect the sound produced **(Lesson 6, 7)**;
  - Explore the structure of the ear and how it produces sound **(Lesson 14)**;
  - Explore how a tube or cone can make a soft sound seem louder **(Lesson 17)**; and
  - Deconstruct and then build a speaker **(Lesson 21, 22)**.
- We find that the use of this CCC to authentically show the connection between life science and physical science is a powerful example of how CCCs can be used to deepen student understanding of the core ideas.

Energy and Matter:

- Students develop an understanding that *the transfer of energy can be tracked as energy flows through a designed or natural system* when they:
  - o explore the transfer of energy through collision across a medium **(Lesson 11, 12, 13)**;
  - o determine what transfers more energy, greater amplitude or frequency **(Lesson 15)**;
  - o Explore how energy is absorbed, reflected, or transmitted through different mediums **(Lesson 18)**; and
  - o Explore how electrical energy can be used to produce sound **(Lesson 21).**

Suggestions for improvement:

In the PRP Feedback response, the writers of the unit clearly explain why Lesson 2-4 are building DCI elements in the elementary grade bands. This explanation is helpful in reviewing the intent for the inclusion of these elements in the unit. It may be beneficial to include this justification in the front matter for teachers as well.

Criteri

Specific evidence from materials and review team consensus reasoning:

Integration of the three dimensions appears in every lesson of this unit. The unit was clearly designed to promote student sense-making of anchoring and related lesson-level phenomena

	by figuring out pieces of DCIs and CCCs through the application of SEPs. The three dimensions hold equal weight in student learning. All lessons have three-dimensional LPEs (described in front matter). The LPEs are color coded to indicate the source and alignment of each dimension: • **Blue bold font: Science and Engineering Practice** • Regular blue font: Quoted text from the relevant Appendix F Practices Matrix • *Italicized font: Specific storyline context (phenomena/question)* • Green font: Alignment to a cross-cutting concept(s) • Orange font: Alignment to the Disciplinary Core Ideas (or pieces of these DCIs) For example: **Develop and use a model** to describe (phenomena) how changes in forces applied to an instrument (being struck or plucked) cause its shape (structure) to change leading it to being repeatedly deformed above and below its initial position (effect) = vibration; use the model to argue whether the structure of other solid objects also changes like this (cause) when they produce sounds (effect). **(Lesson 3)**
	Suggestions for improvement: N/A
Criterion D.	**Specific evidence from materials and review team consensus reasoning:** The purpose and focus of all lessons is to support students in making sense of the phenomenon. Every lesson has a lesson question that is based on the questions the students generated from the DQB. Students answer their questions through hands-on investigation following the "Investigative Routine" (questions, phenomenon, use practices, and what we figure out). Lessons work together in a coherent storyline to help students make sense of the phenomenon of hearing different sounds from a distance as students return to the phenomenon during all lessons to add layers of explanation based on their learning. The navigation routine allows students to reflect on where they have been so far in the unit, and also develop recommendations for what should come next. This makes lessons build off of one another, and lets students develop ownership of the storyline. Attention is paid throughout the unit to revisit the DQB and earlier models to adjust and revise them according to new information that has been gained. The unit is beautifully designed and divided into four different bends, segments of the unit that explores a set of investigations motivated by a related set of student questions. Bend 1 investigates "How do different objects make sound?", Bend 2 investigates "How does sound travel?", Bend 3 investigates "How can we detect sound?", and Bend 4 investigates "How do speakers and microphones work?" The teacher guide is an incredible resource to help a teacher develop coherence for students. It outlines what is figured out during each lesson, and what new questions are developed, and provides guidance for teachers on how to elicit student questions and answers to connect to the next lesson. The unit skeleton breaks down the flow of the storyline, and clearly shows how each lesson builds upon the last to increase complexity in student understanding of the phenomena.

	Suggestions for improvement: N/A
Criterion E.	**Specific evidence from materials and review team consensus reasoning:** This unit authentically integrates physical and life science domains through the lens of the CCC **Structure and Function** when students investigate how the structure of an insect determines the sound it makes **(Lesson 3)** and how the ear detects sound **(Lesson 14).** Opportunities for the integration of life science and physical science in home learning can be seen with **Lesson 14** where students are given the option to gather information about how other organisms hear sounds and how some hear things we can't due to different structures. While this unit primarily lives in the physical science domain, it goes beyond a passing reference to other domains and powerfully integrates elements of the life sciences at the middle school grade band, still in service to figuring out the anchoring phenomenon.
	Suggestions for improvement: N/A
Criterion F.	**Specific evidence from materials and review team consensus reasoning:** The connections to CCSS in ELA and mathematics are strong across the unit. In the teacher guide, the final page of each lesson is an **Alignment to Standards** page, and outlines the ELA and mathematics standards that students were building toward throughout the lesson. For example: • Students build toward **CCSS.ELA-Literacy.SL.6.1** when they participate in collaborative discussion to create questions about the anchoring phenomenon and lesson level phenomena, develop a class consensus models, make sense of information, and figure out what the class should do next. This happens consistently throughout the unit, and can explicitly found in **Lessons 1-13, 15, 17, 21-23;** • Students build toward **CCSS.Math.Content.5.G.A.2** and **CCSS.Math.Content.8.F.B.5** in **Lesson 5** when they use a Logger Lite probe to detect motion in a wooden rod hit by a mallet through a graph of the data, and analyze the graph for patterns in distance vs. time to figure out amplitude and frequency; and • Students build toward **CCSS.Math.Content.6.SP.B.5.B** and **CCSS.Math.Content.6.SP.B.5.C** in **Lesson 15** when they investigate "what transfers more energy – waves of bigger amplitude or frequency?" Students have to calculate how many times farther did the cap move based on different frequency/amplitude. They observe patterns in their data and discover the relationship between frequency vs energy and amplitude vs. energy. Though not explicitly addressed by the authors of the unit, there are many places throughout the unit where students engage in CCSS.ELA related to Science & Technical Subjects. For example: • CCSS.ELA-LITERACY.RST.6-8.7 is addressed when students use provided readings to help construct their model related to the anchoring phenomenon **(Lesson 14, 22);** • CCSS.ELA-LITERACY.RST.6-8.10 is addressed through the various readings provided to students; and CCSS.ELA-LITERACY.RST.6-8.9 is implicit throughout the unit, as students use readings along with experiments, simulations, and videos to make sense of the anchoring phenomenon.

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	Suggestions for improvement: While there are many reading opportunities for the students **(Lesson 3, 4, 5, 7, 13, 17, 21),** it is not clear whether these are optional home learning opportunities because there doesn't appear to be any follow up on the reading activity the next day. **Lessons 14** and **22** were embedded into student sense-making, as students clearly used these readings to help construct their model. It may be beneficial to add more guidance for the teacher on how to use these readings to support student sense-making. With so many scientific readings embedded in the unit, there may be a missed opportunity to address CCSS.ELA-LITERACY.RST.6-8.4-6, related to craft and structure of scientific writing. These standards may be addressed through the addition of specific graphic organizers related to each text that can help students break down how the format of scientific text supports the meaning.

Category II. NGSS Instructional Supports:

	Unit Criteria	None	Inadequate	Adequate	Extensive
Unit Criteria	A. **Relevance and Authenticity**: Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world.				X
	B. **Student Ideas:** Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and respond to peer and teacher feedback orally and/or in written form as appropriate.				X
	C. **Building Progressions**: Identifies and builds on students' prior learning in all three dimensions, including providing support to teachers.			X	
	D. **Scientific Accuracy**: Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning.				X
	E. **Differentiated Instruction**: Provides guidance for teachers to support differentiated instruction.				X
	F. **Teacher Support for Unit Coherence:** Supports teachers in facilitating coherent student learning experiences over time.				X
	G. **Scaffolded differentiation over time:** Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems.				X

Category II Rating: 3

At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C

Criterion A.

Specific evidence from materials and review team consensus reasoning:

The nature of this unit is relevant to student everyday life. Most students have experience with sound and how it changes, musical instruments, speakers, cell phone tones, and other phenomena experienced throughout the unit. To ensure that learning is authentic, all phenomena are experienced as directly as possible to create a common experience amongst students that will drive the class learning.

Some examples of phenomena experienced directly include:

- In **Lesson 1**, sound is generated by a record on a lazy-susan with a needle attached to a cone. This allows students to physically see from where the music is originating;
- In **Lesson 2,** magnifiers allow students to see what might be causing different sounds to be generated; and
- As lessons progress, students generate sounds with instruments and other implements and measure the results with sensors.

Students are also prompted throughout the unit to make connections to their own prior knowledge related to the phenomena. For example:

- In **Lesson 1,** students discuss places that they have heard sound coming from; and
- The **Lesson 16** student handout asks, "Discuss any experience you've had where the sound from a sound source changed as you got closer or further from the sound source."

As a point of relevancy to students, all learning experiences are dependent on the questions that they have developed in previous lessons. This provides students with the feeling of

<table>
<tr><td></td><td>autonomy in the work that they complete, and contributes to a positive classroom culture of figuring out together.</td></tr>
<tr><td></td><td>Suggestions for improvement:
N/A</td></tr>
<tr><td rowspan="2">Criterion B.</td><td>Specific evidence from materials and review team consensus reasoning:
Students have many opportunities to express, clarify, justify, interpret, and represent their ideas throughout the unit. For example:
Initial Model (Lesson 1) and Incremental Tracker (used throughout unit) allows students to represent their ideas through illustration;
Scientists Circle (Lesson 1, 3, 8, 13, 15) is used for mediated whole group discussion when students are coming to consensus on a set of ideas. This strategy promotes peer-to-peer feedback on ideas;
Student activity sheets (used throughout unit) provide student opportunity to represent ideas in written form, and give teacher an opportunity to provide feedback;
The driving question board (created Lesson 1, displayed and utilized throughout unit) allows students to ask, prioritize, and align their questions with those of their peers, and refine questions as new evidence becomes available;
Small group discussion (Lessons 1, 2, 6, 8, 11, 13, 14, 19, 21, 23) are a way to allow students to share ideas and build their understanding. Small group listening and speaking routines are provided within the handouts to help teachers establish norms around student discourse. The norms presented allow students to establish knowledge and participate in scientific argumentation based on evidence that they collect; and
The front matter (J) establishes norms and strategies that teachers can use in the four basic types of discussion that can facilitate science learning: Generating and Prioritizing Questions Discussion, Initial Ideas Discussion, Building Understandings Discussion, and Consensus Building Discussion.</td></tr>
<tr><td>Suggestions for improvement:
N/A</td></tr>
<tr><td>Criterion C.</td><td>Specific evidence from materials and review team consensus reasoning:
Expected student prior learning is identified throughout the unit within the Getting Ready: Teacher Preparation pages for each lesson. This section of the teacher guide includes background knowledge for the teacher, which may outline the content knowledge that students are expected to have, and alternative student conceptions, which outlines incomplete ideas that students may have about the content. Based on student prior knowledge, additional investigations may be suggested to help build prior knowledge that students are missing. Some examples include:
Lesson 9: If students do not have prior knowledge from PS1 in grade 5, that air is matter and therefore has mass, it is recommended to complete additional investigation in step 3; and
Lesson 11: If students haven’t developed lines of evidence from previous grades (PS1 in grade 5) that solids, liquids, and gases are made of particles and that the spacing between those particles is different for a solid and liquid vs. a gas, and that the particles in liquid or gas can move, you may need to add additional supplemental lessons before this one.</td></tr>
</table>

	Prior knowledge and student alternative conceptions related explicitly to the CCCs is found in the teacher notes along the side of the teacher guide, in a box called **Supporting Students in Using Cross-Cutting Concepts**. These boxes are found in **Lessons 4,5,6, and 9**, and provide information about what students may not understand about a CCC and point out an opportunity to address that with students. Student prior knowledge is elicited through an embedded pre-assessment in **Lesson 1**, and an **optional pre-assessment** that can be completed prior to Lesson 1. In the **front matter**, the embedded pre-assessment is broken down to explain what prior knowledge is expected in terms of content, and provides the teacher guidance on how the unit can be modified if students show a strong understanding of these ideas. For example, the front matter notes, "If most of your students show idea 2), then lesson 12, can be reduced to a 5-10 minute review" (page 14). Progression of student learning throughout the lesson is extensive. The initial lessons revisit the understanding of sound that should be developed in the K-2 and 3-5 grade bands in order to reinforce student learning that is a pre-requisite to this learning, and engages students in the empowering realm of "figuring out." There is extensive support provided throughout the teacher guide for guiding student discussions to build one lesson off of another, and every lesson incorporates the "navigation routine" where students look back on the previous lessons, and look forward. Looking back allows student to reflect on what they have learned and what they still wonder, while looking forward empowers students to guide their own learning. Students complete "next step" questions at the end of most student activity sheets. Students also keep track of their own progression throughout the unit by reflecting on their learning using the Incremental Model Tracker.
	Suggestions for improvement: This section would be rated extensive if prior knowledge was clearly identified at the **element level** for all three dimensions. Prior knowledge should be explained for each dimension. It may be beneficial to explain what prior knowledge or skill is being elicited from the initial model that acts as an embedded pre-assessment in **Lesson 1**, and what can be done if students do not show proficiency in the SEPs or CCCs at this level. It may also be helpful to explicitly identify or label expected prior knowledge of students at the element level for the SEPs, CCCs, and DCIs in the **Getting Ready: Teacher Preparation** resource.
Criterion D.	**Specific evidence from materials and review team consensus reasoning:** The teacher handout provides "Background Knowledge for Teacher Only" which is scientifically accurate, research based, and guides the teacher to ensure scientific accuracy in student development of knowledge. The teacher guide is also designed to help the teacher elicit appropriate questions from students that will lead to accurate scientific understanding of the phenomena. Scientific terminology and alternative student conceptions are also provided.
	Suggestions for improvement: N/A

Criterion E.	**Specific evidence from materials and review team consensus reasoning:** The **front matter** presents teachers with recommendations for differentiated instruction. Recommendations include: • Allow students to investigate novel questions that arise during lessons but are not directly related to the storyline presented as extension activities; • Allow students to attempt assessments with or without co-constructed incremental model tool and "Gotta Have It" checklist; and • Some lessons provide differentiated options for home learning (for example, in **Lesson 7**, students may choose from two different investigations or a reading on how humans produce sounds, and allows for student-selected differentiation). The **front matter** provides opportunities for teachers to present only sections of the storyline to suit the needs of their classroom. Throughout the unit, lessons provide differentiation strategies: • **Lesson 1:** Class work or home learning; • **Lesson 3:** Different method of demonstrating concepts; • **Lesson 3:** When readings can be used; • **Lesson 7:** Providing student investigation choice; • **Lesson 9:** Changes in writing based on student engagement; • **Lesson 13:** Differentiated Assessment Provided; • **Lesson 14:** Partner, Group Structure; and • **Lesson 14:** Additional reading on how humpback whales produce and hear sounds. Summative assessments presented in **Lessons 7** and **13** have alternative versions to use with students who many need questions broken into smaller steps or sub-pieces. Learning throughout the unit is multi-modal. Students have various opportunities to express their understanding of the science ideas in many ways (illustration of models, written work, reading, discussion, etc.).
	Suggestions for improvement: It may be beneficial to provide readings at various lexiles to support students who are English language learners, have special needs, or read below reading level. If unable to provide varied levels of reading, resources like graphic organizers to help pull important information from the text may be helpful for this same population of students.
Criterion F.	**Specific evidence from materials and review team consensus reasoning:** The **teacher guides**, **front matter**, and **unit skeleton** provide clear support on the coherent format of the unit. Each lesson provides teachers with the opportunity to cultivate student questions for the goal of learning. The teacher guides provide guidance on what questions to look for from students, and how to elicit appropriate questions by using certain prompts.

	The teacher guide also provides guidance on what to do if student questions or comments do not follow the storyline. For example: • **Lesson 2:** "If students don't raise the idea of looking at instruments next, another way to build coherence to the next lesson would be …" • **Lesson 5:** "If students don't raise this idea, look back at question from the DQB…" • **Lesson 9:** "If students don't raise the idea of trapping the air around the sound source, here are some suggested prompts…" All three dimensions are incorporated into the design of the lesson, and are clearly outlined in the teacher guide. The teacher guide provides strategies and supports for implementing the lessons, but beyond that provides a multitude of supports in how to run a classroom that truly embodies the vision of the National Research Council's *Framework for K-12 Science Education*, with students at the center of scientific discovery**.** The notes along the side of the teacher guides provide various supports for illuminating possible misconceptions and alternative conceptions in students, providing differentiation, and supporting understanding within the SEPs and CCCs that are background to the LPEs. The unit front matter also provides strategies for the teacher to facilitate student discussion that supports sense-making in all three dimensions.
	Suggestions for improvement: N/A
Criterion G.	**Specific evidence from materials and review team consensus reasoning:** During discussion, the teacher carefully scaffolds students to ask scientific questions and guides the students to list investigations they can conduct to help answer the questions. This encourages students to take responsibility in making sense of the phenomenon. Lessons progress from reviewing basic understanding to building on that understanding. One question drives a lesson and the lesson generates a more complex question which is addressed in subsequent lessons. Students become more independent as the unit progresses, and have the opportunity to guide their own learning. Some examples include: • In **Lesson 17**, students create and test designed structure for amplifying sound. The design of the structure is driven by individual student interests and questions; and • The incremental model tracker and "Gotta Have It" checklist are tools completed by the entire class up until **Lesson 13.** After this point, students are encouraged to continue using these tools, but are also offered the freedom to record information for class in another way that is more comfortable for them. The writers of this unit also provide teachers with the autonomy to make decisions in terms of the scaffolding of their lessons based on their student population. For example: • **Lesson 1:** Class time or home learning to capture initial questions; and • **Lesson 22:** Options for what to do if students want to continue working on task.
	Suggestions for improvement: N/A

Category III. Monitoring NGSS Student Progress

		Evidence of Quality? None	Inadequate	Adequate	Extensive
Unit Criteria	A. Monitoring 3D student performances: Elicits direct, observable evidence of three-dimensional learning; students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions.				X
	B. Formative: Embeds formative assessment processes throughout that evaluate student learning to inform instruction.				X
	C. Scoring guidance: Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.				X
	D. Unbiased tasks/items: Assesses student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.				X
	E. Coherent Assessment system: Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.				X
	F. Opportunity to learn: Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback				X

Category III Rating: 3

At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion

Criterion A.

Specific evidence from materials and review team consensus reasoning:

Three-dimensional student performance is monitored throughout the unit. Throughout the teacher guides, support is provided to teachers around what they should be hearing in terms of student questions and responses that shows three-dimensional learning progressions.

Full class artifacts, such as the DQB and Consensus Model, are displayed through the course of the unit. This provides observable evidence of full group three-dimensional learning as students are working together to figure out the anchoring phenomenon.

Formative assessment is embedded throughout the lessons as a method of observable learning. The front matter identifies what student artifacts can be used to provide evidence of three-dimensional learning related to the LPEs. For example, it might identify which question on the student activity sheet can be used to collect evidence of student progress or what can should be observed in student models. Specifically:

- **Lesson 4:** Questions 2 and 3 on the student activity sheet targets the LPE of the lesson that shows students ideas;
- **Lesson 8:** The group/partner models constructed for the gallery walk; and
- **Lesson 18:** Student responses to questions 2-5.

Five summative assessment tasks are presented, with three-dimensional answer guides and rubrics to assess student performance in all dimensions. Each summative task asks students to apply their gained scientific knowledge to a new phenomenon.

Suggestions for improvement:

N/A

Criterion B.	**Specific evidence from materials and review team consensus reasoning:** Several examples of evidence of formative assessments embedded throughout the unit through activity sheets and student models are listed in Criterion A. In **Lesson 1,** and many subsequent lessons, the teacher circulates as students work in partners or small groups, observes, asks probing questions, and informally evaluates understanding. The teacher guide provides support on probing questions to use while circulating the room to evaluate student understanding. The teacher has many opportunities to formatively assess student progress through the extensive use of modeling and consensus building. Entrance and exit tickets are suggested as excellent opportunities for the teacher to formatively assess student understanding. Teachers can ask the following questions from the Unit Front Matter to help assess/reinforce what the students are figuring out: • What did we figure out in this lesson? • What new question does this raise for us? • What ideas do you have for how we might go about investigating this today/next time?
	Suggestions for improvement: N/A
Criterion C.	**Specific evidence from materials and review team consensus reasoning:** Scoring guidance is provided for the five summative assessment pieces. Scoring guidance includes answer keys to the summative assessments in **Lesson 7** and **Lesson 13**, and a three-dimensional rubric for the final model. These assess whether students can show the following: • Explain waves, forces, and vibration (DCI); • Describe patterns, structure, and cause and effect (CCC); and • Show how different components in the model interact (SEP). The answer keys and rubrics are designed to help teachers interpret student performance in all three dimensions. Sample student work is included with the summative assessments, in the front matter, and throughout the unit to provide teacher with guidance on what to look for in student work.
	Suggestions for improvement: N/A
Criterion D.	**Specific evidence from materials and review team consensus reasoning:** The summative assessment tasks **(Lesson 7, 13 and 20)** are based on phenomena that students have experienced in daily lives (dropping rock into water, hearing music from other cars, etc.). These tasks are unbiased because all students have had multiple opportunities to develop the understanding that is required to successfully complete the assessments. To ensure that tasks are accessible to all students, videos are also used to help students engage in the phenomenon. For example, **Lesson 7** shows a video of harp in slow motion. Some

	assessment items also have pictures provided to help students understand the phenomenon it is addressing (such as unit assessment Item 2 and Item 3).
	Suggestions for improvement: While this unit does not show bias in the ability of students to gain knowledge, it is worth noting that some students may be hard of hearing, and not be able to participate in all aspects of the activities. At a middle school level, students may be uncomfortable with this difference in their abilities. We suggest that if this situation arises, the teacher take the opportunity to discuss with students how sound will be visualized in many ways throughout the unit, and that they will still be able to fully participate in the class activities.
Criterion E.	**Specific evidence from materials and review team consensus reasoning:** Assessment opportunities are prevalent throughout the unit, and the assessment of three-dimensional learning helps to build a coherent storyline within the class. The Unit Front Matter includes **Section H: What Assessment Resources Are There?**, which outlines the various ways that assessments can be used throughout the unit to guide student learning. The expectations within the assessments build with the student understanding. Students are expected to utilize their learning in a progressive system of formative and summative assessment tools. Examples of assessment include: • Pre-Assessment o A formal pre-assessment is presented as an option to complete before **Lesson 1**, or between **Lessons 1** and **2.** o A pre-assessment is embedded in **Lesson 1**, the construction of an initial model, includes opportunities to modify upcoming lessons based on student performance. This opportunity for teacher autonomy provides coherence in the storyline that is personalized for a specific class. • Formative Assessment o Formative assessment tasks are provided for each lesson related to the LPE in the Unit Front Matter. o The context for many of the formative assessment tasks lie in the student activity sheets or home learning. o Support for using entrance and exit tickets and the navigation routine as formative assessment is provided in the Unit Front Matter. • Summative Assessment o Five summative assessment tasks are provided throughout the unit in **Lessons 3, 7, 13, 20, and 23**. o Students independently complete each summative task. o The summative assessments cover LPEs from previous lessons. For example, the summative assessment in **Lesson 20** covers LPEs from **Lessons 6, 13-19** (Unit Front Matter, page 19). o The summative assessments are based on new phenomena where students have to transfer and apply their understanding into a new setting. o Each summative assessment task contains scoring guides, examples of past student work, and/or rubrics to assess three-dimensional learning. • Self-Assessment o Rubric provided for students to self-evaluate during discussions (See document **Self-Evaluation: Engaging in Classroom Discourse**) in small group or whole group settings.

	o Students evaluate their own understanding through the creation of the **Incremental Model Tracker** throughout the lesson.
	Suggestions for improvement: N/A
Criterion F.	**Specific evidence from materials and review team consensus reasoning:** As mentioned in other criteria in this category, this unit provides multiple opportunities for students to demonstrate performance of SEPs connected with their understanding of DCIs and CCCs. This is especially evident through the development, revision, and use of models throughout the unit. In Lesson 3, students have the opportunity apply their learning to a new situation when they are asked to "apply their model to a new instrument." There is ample opportunity for feedback, from both the teacher and peers through small and whole group discussions.
	Suggestions for improvement: N/A

Summary Comments

Overall, the reviewers believe that this unit truly embodies the vision set forth in *A Framework for K-12 Science Education*, as evidenced by almost exclusively extensive ratings. We feel that the biggest strength in this unit design is the sheer magnitude of support that is provided to teachers using the unit through the front matter and teacher guide; any teacher could pick up this unit and provide a coherent, high-quality NGSS learning experience to their students. The careful selection of anchoring and lesson-level phenomena and the use of student questioning to drive three-dimensional learning allows students to have ownership over their learning, which authentically drives the class to figuring out the phenomenon. We would also like to commend the writers of the unit for the supports that they have provided on promoting student discourse, which in turn promotes a shift in classroom culture to one that truly learns together.

However, there is one area of the unit that we feel should have further review by the writers of the unit. There are a couple resources referenced throughout the teacher guide and front matter that we were unable to locate. These include:

- Optional Pre-Assessment
- Alternative Lesson 7 Assessment.

Unit Rating Scale for Category I (Criteria A–F): **3**: At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C **2**: At least some evidence for all unit criteria in Category I (A–F)**;** adequate evidence for criteria A–C **1**: Adequate evidence for some criteria in Category I, but inadequate/no evidence for at least one criterion A–C **0**: Inadequate (or no) evidence to meet any criteria in Category I (A–F)
***Unit* rating scale for Category II (Criteria A-G):** **3**: At least adequate evidence for all criteria in the category; extensive evidence for at least two criteria **2**: Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A **1**: Adequate evidence for at least three criteria in the category **0**: Adequate evidence for no more than two criteria in the category
Unit Rating scale for Category III (Criteria A–F): **3**: At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion **2**: Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A **1**: Adequate evidence for at least three criteria in the category **0**: Adequate evidence for no more than two criteria in the category
Overall Rating: **E: Example of high quality NGSS design**—High quality design for the NGSS across all three categories of the rubric; a lesson or unit with this rating will still need adjustments for a specific classroom, but the support is there to make this possible; exemplifies most criteria across Categories I, II, & III of the rubric. (total score ~8–9) **E/I: Example of high quality NGSS design if Improved—**Adequate design for the NGSS, but would benefit from some improvement in one or more categories; most criteria have at least adequate evidence (total score ~6–7) **R: Revision needed—**Partially designed for the NGSS, but needs significant revision in one or more categories (total ~3–5) N: Not ready to review—Not designed for the NGSS; does not meet criteria (total 0–2)