How Can Sound Make Something Move?
EQuIP Rubric for Science Evaluation

Developer/Curriculum: OpenSciEd
Unit Name: How Can Sound Make Something Move?
Grade: Middle School
Date of Review: July 2019
Overall Rating (N, R, E/I, E): E
Category I: NGSS 3D Design Score (0, 1, 2, 3): 2
Category II: NGSS Instructional Supports Score (0, 1, 2, 3): 3
Category III: Monitoring NGSS Student Progress Score (0, 1, 2, 3): 3
Total Score (0–9): 8

Click here to see scoring guidelines

This review was conducted by the Science Peer Review Panel using the EQuIP Rubric for Science.

Category I Criteria Ratings		Category II Criteria Ratings		Category III Criteria Ratings	
A. Explaining Phenomena/Designing Solutions	Extensive	**A. Relevance and Authenticity**	Adequate	**A. Monitoring 3D Student Performances**	Adequate
B. Three Dimensions	Adequate	**B. Student Ideas**	Adequate	**B. Formative**	Adequate
C. Integrating the Three Dimensions	Extensive	**C. Building Progressions**	Adequate	**C. Scoring Guidance**	Adequate
D. Unit Coherence	Extensive	**D. Scientific Accuracy**	Extensive	**D. Unbiased Tasks/Items**	Adequate
E. Multiple Science Domains	Adequate	**E. Differentiated Instruction**	Adequate	**E. Coherence Assessment System**	Extensive
F. Math and ELA	Adequate	**F. Teacher Support for Unit Coherence**	Extensive	**F. Opportunity to Learn**	Extensive
		G. Scaffolded Differentiation Over Time	Adequate		

Summary Comments

Thank you for your commitment to students and their science education. Achieve is glad to partner with you in this continuous improvement process. The unit is strong in several areas, including material to support the teacher as the expert facilitator, the sequencing of lessons, the alignment of material (Teacher Edition, Student Edition, power point), and the *Assessment System Overview*. The reviewers were impressed by the number of positive, systematic updates made to this unit since our initial review. We feel that the updates help ensure adherence to the criteria of the EQuIP Rubric and hope that these systematic updates are retained in the development of future units.

During revisions, the authors should pay close attention to the following areas:

- Explicit connections to primary CCC and SEP *elements* to focus teacher guidance and student learning on the targeted elements of each of the three dimensions.
- Guidance for differentiating instruction or scaffolding differentiation over time for students who have already met the lesson-level performance expectations. The current version of this unit provides minimal teacher support for advanced learners. Adding opportunities for advanced learners will provide teachers with support to meet the needs of all student learners.
- Opportunities that allow students to apply new learning to unique or novel situations.

Note that in the feedback below, black text is used for either neutral comments or evidence the criterion was met and purple text is used as evidence that the criterion was not met.

Category I. NGSS 3D Design

Score: **2**

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)*

I.A. Explaining Phenomena/Designing Solutions: Making sense of phenomena and/or designing solutions to a problem drive student learning.

Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving.

The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems.

When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.

Rating for Criterion I.A Explaining Phenomena/Designing Solutions: Extensive

(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that learning is driven by students making sense of phenomena and/or designing solutions to a problem because the unit material is driven by students making sense of the central phenomenon, sound from a truck speaker causing a store window to vibrate. Student learning is focused on supporting students to make better sense of a sound source, the medium through which sound travels, and the receiver of sound. Students regularly return to the central phenomenon to add layers of explanation. For example:

- Lesson 1 - Students watch a video of the central, anchoring phenomenon—sound from a truck appears to cause vibrations in a window located across the parking lot—and then observe a speaker set up in the classroom. They record observations, develop initial models and create a list of questions on a Driving Question Board (DQB) as a frame for future investigations.

- Lesson 2 - Students observe instruments and speakers placed at stations around the classroom. In small groups, they move through the stations making and recording observations about the movement of speakers and instruments when they are played or struck. “In addition, even though “vibration is a back-and-forth movement” is a piece of a first-grade Disciplinary Core Idea (DCI), the cause of vibrations and the nuances of the type of motion are a deeper dive into a causal mechanism of how sound waves are generated and able to propagate within a medium. Students have experiences with stringed instruments and trampolines that they will draw on. They may be surprised, however, to see metal or wood deforming and may need to carefully analyze images in the slow-motion videos in order to see the shape changes occurring in each object. The idea that an object changes shape (is deformed with the force applied) by bending beyond its original shape and continuing in a back-and-forth motion before retaining its original shape is not a trivial idea. This sets the foundation for how sound travels, which we will get to in future lessons” (Teacher Edition, page 58)
- Lesson 4 - Students use a laser-mirror device/laser setup to observe the motion of solid objects when different forces are applied and sounds are made.
- Lesson 4 - Students use a stick/sound maker and motion detector to observe vibrations on a distant time graph. Students record and analyze data looking for patterns that can help explain how objects move when they are vibrating.
- Lesson 5 - Students utilize the sound maker motion detector setup to observe and record motion data produced by sticks of varying lengths and analyze patterns in pitch. “Apply ideas to better explain the anchoring phenomenon. Project slide H. Ask students to think back to the truck and the stereo. How might they explain how the speaker is making so many sounds (loud, soft, high pitch, and low pitch). Have students share out a few ideas” (Teacher Edition, page 135).
- Lesson 7 - Students weigh air that has been trapped in a container with a sound source (cell phone) and make claims about what is traveling between the sound source and the receiver. Students refine their initial models by adding what they think is happening between the speaker and the moving window (Teacher Edition, page 172).
- Lesson 8 - Students observe a video of a cell phone ringing after being placed within a vacuum jar. Students make observations and state claims about what is needed for sound to travel from source to receiver.
- Lesson 10 - Students use a computer simulation to figure out how particles move in response to changes in pitch and volume.
- Lesson 12 - Students view a video of an ear drum, read an article and visit websites to learn how the human ear responds to vibrations.
- Lesson 13 - Students conduct an investigation to figure out how energy is transferred between particles (marbles).
- Student questions or prior experiences with the phenomena create a need for students to engage in learning. Materials provide structured support to help teachers draw out these connections and use them to motivate student learning. For example, “Brainstorm examples of other times

students have observed a sound being made, a sound traveling, or a sound being received like in the truck video" (Teacher Edition, page 30).

Suggestions for Improvement

N/A - The unit materials included extensive evidence of explaining phenomena.

I.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.

Provides opportunities to *develop and use* specific elements of the SEP(s).

Provides opportunities to *develop and use* specific elements of the DCI(s).

Provides opportunities to *develop and use* specific elements of the CCC(s).

Rating for Criterion I.B. Three Dimensions: Adequate

(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions because each of the unit's lessons centers around a three-dimensional learning goal, allowing for adequate use of each of the three dimensions in student sense-making of the phenomenon.

Science and Engineering Practices (SEPs): Adequate

The reviewers found adequate evidence that students have the opportunity to use or develop the SEPs in this unit because the SEP elements are grade appropriate and students engage in these elements in service of making sense of the central phenomenon.

Evidence of students engaged in grade-appropriate SEPs can be found throughout the unit. A few examples are as follows:

Developing and Using Models

In Lesson 1, the teacher is told to "remind students that everyone heard the music and saw the window shaking, but we may have different explanations for why a sound coming from one thing could make another thing far away move.Ask students to draw on their handouts how they might explain the question, 'How does the sound coming from one thing (like the speaker) make another thing far away (like the window) move?' Cue them to show what is happening in each of the three places indicated. Emphasize to students that on their models they should be showing what's happening at the zoomed-in scale at three places: the surface of the speaker, in the air between the speaker and the window, and at the surface of the window" (Teacher Edition, page 43). This allows students to use the element: *Develop a model to describe unobservable mechanisms.*

In Lesson 2, "Co-Construct a Model. Tell students that we will use this table to show how one object, the drum moves while it is vibrating. Say: Let's try to draw out a representation of how it was moving and why it was moving the way it was" (Teacher Edition, page 64). This allows students to use the element: *Develop a model to describe unobservable mechanisms.*

Asking Questions and Defining Problems

In Lesson 1, "Ask students to take the last few minutes of class to record at least two questions That the class could investigate to figure out more about what's happening in the phenomena the class has brainstormed so far" (Teacher Edition, page 50). This allows students to use this element: *Ask questions that come from careful observation of phenomena, models or unexpected results, to clarify and seek additional information.*

In Lesson 7, "Project slide I. Ask students to take out the initial models that they started class with and to focus on what they showed traveling between the speaker and the window. Instruct students to use their initial model to answer this question on a sticky note that they place on their model: "In your initial model, what claim did you make about what's traveling between the speaker and the window?" (Teacher Edition, page 172). This allows students to use the element: *Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information*.

Engaging in Argument from Evidence

In Lesson 2, "At the end of this lesson or for home learning is a good opportunity for students to self-assess using the Self-Assessment (tool). Helping students reflect on their progress in giving and receiving feedback will help build their skills in this important area" (Teacher Edition, page 67). This allows students to use the element: *Respectfully provide and receive critiques about one's explanations, procedures, models and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.*

In Lesson 3, "Ask what claim can we make based on the evidence we found today? How does changing the force affect the sound? Discuss claims and the evidence to support them. If students need support to explain their reasoning, display slide L for more prompts to help them arrive at the conclusion that more force transfers more energy, which causes more vibrations and louder sounds" (Teacher Edition, page 93). This allows students to use the element: *Construct, use and/or present an 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*.

Using Mathematics and Computational Thinking

In Lesson 5, Students collect data with a motion detector and produce graphs of the amount of time a vibration takes (frequency) for the sound sources to produce differently pitched sounds (Teacher Edition, page 123). This allows students to use element: *Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.*

In Lesson 5, students use mathematical representations of position versus time graphs generated from a tool used to scale up the vibrations of an object to describe wave patterns and support scientific conclusions about how objects move when they make higher and lower pitched sounds (Teacher Edition, page 123). This allows students to use the element: *Use mathematical representations to describe and/or support scientific conclusions and design solutions.*

In Lesson 10, students run a computational simulation exploring how particle collisions propagate across a medium from a vibrating source. Students analyze data to better understand patterns in wavelengths and compression of particles as energy moves across the system (Teacher Edition, page 199). This allows students to use the element: *Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.*

In Lesson 13, students use methods for calculating mean and median and discuss the results of different groups aimed at finding patterns in groups' findings and noting any outliers to the general trends that the class identifies (Teacher Edition, page 252). This allows students to use the element: *Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems.*

Disciplinary Core Ideas (DCIs): Adequate

The reviewers found adequate evidence that students have the opportunity to use or develop the DCIs in this unit because there are sufficient DCI grade-appropriate elements for the length of the materials and the core of the grade-appropriate elements that the students are engaged in are in service of students making sense of the phenomenon: sound from a speaker can cause a window across the parking lot to vibrate.

The unit addresses several appropriate disciplinary core ideas at the element level that students are able to use to make sense of the initial phenomenon. Some examples are outlined below:

- **PS4.A Wave Properties**

  In Lesson 4, "Say, if scientists or engineers think that the same number of vibrations is occurring in the same amount of time, so that if you double that time you get double the vibrations and if you triple that time you get triple the vibrations, then say the waves have the same 'frequency.' The frequency is the number of peaks or valleys that you would see in a single second. Direct students to record this definition in their notebooks, along with a diagram or drawing to help them remember it" (Teacher Edition, page 116). This allows students to begin to build toward the

element: *A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.*

In Lesson 4, "Say, Scientists and engineers use a single word to refer to this vertical distance between the midpoint (resting, starting point) and a high point or low point. They refer to that distance as 'amplitude'. This is a word you have earned - you understand well what it is. So, let's record it in our science notebooks. Then we will share out and add our agreed upon definition to our word wall" (Teacher Edition, page 115). This allows students to begin to build toward the element: *A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.*

In Lesson 8, "So in the video, the vacuum pump sucked out all the air from the container leaving behind an empty space with no matter at all. And we agree that we couldn't hear sounds coming from inside the container once all the air was removed. But we also had this question about whether sound could travel if there was something in the container besides air (Teacher Edition page 181). This allows students to build toward the element: *A sound wave needs a medium through which it is transmitted.*

In Lesson 8, "This is an opportunity to introduce students to a new multiple-meaning word that they can use for a substance made of matter that sound can travel through: *medium*. Air, water, and solids like the walls of the container are all media (plural for medium) that sounds can travel through. Add this word to the word wall" (Teacher Edition, page 184). This allows students to build toward the element: *A sound wave needs a medium through which it is transmitted.*

In Lesson 10, "Recognize that the difference in spacing between the bands is called wavelength. Point out that as they mentioned before, the distance between two neighboring compression bands (bands of high density) doesn't change. This might be easiest to see in frame 2. Students might have heard the word *wavelength* before. This allows students to build toward the element: *A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.*

Crosscutting Concepts (CCCs): Adequate

The reviewers found extensive evidence that students have the opportunity to use or develop the CCCs in this unit because there are sufficient CCC elements for the length of the materials and the core of the grade-appropriate elements that students are engaged in are in service of students making sense of the phenomenon, sound from a speaker can cause a window across the parking lot to vibrate.

The Crosscutting Concepts of Patterns, Scale, Proportion and Quantity, and Structure and Function are utilized throughout the unit at the appropriate grade-level element level as illustrated in the examples below:

- **Patterns**

  In Lesson 3, "Explore other patterns we saw in our data. Say ok so we found some good evidence that even stiff, hard, not-meant-to-make-sounds kinds of things vibrate when they make sounds. But what other patterns did you discover in our investigation?" "When more force is applied to an object it causes bigger vibrations and therefore louder sounds" (Teacher Edition, pages 92–93). This allows students to use the element: *Patterns can be used to identify cause and effect relationships.*

  Lesson 4, "Direct students to look for patterns among the four graphs and describe those patterns in their science notebooks. They should specifically look for similarities and differences between the graphs" (Teacher Edition, page 112). This allows students to use the element: *Graphs, charts, and images can be used to identify patterns in data.*

  Lesson 5, "Say, we are now going to take some time to analyze the data we collected to look for patterns in the motion of the stick." "Write one 'What I see' (WSI) comment for each pattern they notice." "Engage students in a whole class discussion about the patterns they noticed in the graphs. Be sure to ask students to get up and point to the graph features (on the board) as they talk" (Teacher Edition, page 132). This allows students to use the element: *Graphs, charts, and images can be used to identify patterns in data.*

- **Scale, Proportion and Quantity**

  Lesson 3, "Remember in previous units we have used the idea of scale. Sometimes when we can't observe things at one scale (like a distance or speed), we can change the scale to make them more visible. When we looked at slow-motion videos of instruments, we had changed the scale of the speed so we could really see what was going on. So, I was thinking about what we could do to zoom in on or magnify any vibrations that might be happening on the table (Teacher Edition, pages 87–88). This lesson claims that this activity allows students to build toward this CCC element, but there isn't evidence of student use of this element in the lesson: *Phenomena that can be observed at one scale may not be observable at another.*

- **Structure and Function**

  Lesson 12, "So what we're really curious about now is how the detector (in this case, our ears) works. All of our questions are related directly to the structure and function of the ear, so it makes sense to start there. When we look at the ear try to figure out how that detector helps us hear sounds" (Teacher Edition, page 239). This lesson claims that this activity allows students to build toward this CCC element, but there isn't evidence of student understanding of the element, as students are just following the teacher's instructions: *Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their functions depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.*

Suggestions for Improvement

SEPs

- When identifying the elements of the SEP being addressed, clearly delineate elements that are the primary focus from those that are secondary as well as those that are not in the middle school grade band. It is important to include necessary elements even if they are not in the middle school grade band but indicating them as such will be helpful to the end users.
- The Engaging in Argument from SEP should involve multiple, plausible claims based on evidence and scientific reasoning about something unknown (from students' experience) and include a counter argument
- Several CCSS Mathematical standards were listed. Explicitly connecting these with grade appropriate elements of the SEP Using Mathematics and Computational Thinking would emphasize cross-curricular connections and support student learning of this SEP.
- Considering adding the element of the SEP for each lesson level performance expectation.
- Expand upon Lesson 8, "Display slide B. Introduce to students that there are two competing claims that could answer this question: either sound needs air to travel to our ears, or it doesn't." To meet the element: *Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts* students must move beyond comparing to critiquing the elements.

DCIs

- When identifying the elements of the DCI being addressed, clearly delineate elements that are the primary focus from those that are secondary as well as those that are not in the middle school grade band. It is important to include necessary elements even if they are not in the middle school grade band but indicating them as such will be helpful to the end users.
- Consider including PS1.A Structure and Properties of Matter, element: *In a liquid, the molecules are constantly in contact with others; in a gas, there are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.*
- Considering adding the element of the DCI for each lesson level performance expectation.

CCCs

- Consider having students determine the CCC that will help them make sense of something new.
- Considering adding the element of the CCC for each lesson level performance expectation.
- In Lesson 3, the teacher tells the students that *Phenomena that can be observed at one scale may not be observable at another.* Consider adding opportunities to have the students develop and demonstrate their own understanding of this element.
- Consider opportunities to have students develop their understanding of the element *Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their functions depends on the shapes, composition, and relationships among its parts; therefore,*

complex natural and designed structures/systems can be analyzed to determine how they function. In Lesson 12, the students currently seem to just be following teacher directions rather than using the CCC.

I.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.

Rating for Criterion I.C. Integrating the Three Dimensions: Extensive

(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena and/or designing solutions to problems because there are numerous events where all students are expected to figure something out in a way that requires grade-appropriate elements of all three dimensions of the standards. The three dimensions intentionally work together to help students adequately explain the central phenomenon.

There are several instances in which students are required to integrate the three dimensions in order to gather information essential to figuring out the phenomenon:

- Lesson 2: Students figure out there is a cause and effect relationship between objects bending and changing shape and the production of sound. They analyze and interpret data (SEP) looking for patterns (CCC) to explain the relationship between force on an instrument and vibrations (PS4.A) (Teacher Edition, page 55).
- Lesson 3: Students figure out there is a cause and effect relationship between force on an object, the amplitude of motion graphs and the loudness of the sound produced. They analyze and interpret data (SEP) looking for patterns (CCC) to figure out the relationship between energy exerted on an object, amplitude of motion graph and the volume of sound (PS4.A) (Teacher Edition, page 81).
- Lesson 4: Students use mathematical representations (SEP) of position versus time graphs generated from a tool used to scale up the vibrations of an object to describe wave patterns (CCC) and support scientific conclusions about how objects move when they make louder or softer sounds (PS4.A) (Teacher Edition, page 99).
- Lesson 6: Students construct an argument (SEP) using evidence from graphs to support an explanation for which patterns (CCC) of frequency and amplitude of a wave (PS4.A) are indicators of attributes of sounds that we can hear (Teacher Edition, page 143).
- Lesson 7: Students use evidence and apply scientific ideas to construct an explanation (SEP) that sound does not travel on air particles from the sound source to the ear (Energy and Matter CCC) because the mass of a closed container does not decrease (PS1.A) when a sound is heard from inside the container (Teacher Edition, pages 170–171).

- Lesson 11, students observe how striking a drum causes salt to jump on stretched piece of plastic wrap. Students model (SEP) how sound energy flows (Energy and Matter CCC) from the drum to the plastic wrap through the particles in the medium (PS4.A) of air (Teacher Edition, pages 221–224).

Suggestions for Improvement

N/A - The unit materials included extensive evidence of integrating the three dimensions.

I.D. Unit Coherence: Lessons fit together to target a set of performance expectations.

Each lesson builds on prior lessons by addressing questions raised in those lessons, cultivating new questions that build on what students figured out, or cultivating new questions from related phenomena, problems, and prior student experiences.

The lessons help students develop toward proficiency in a targeted set of performance expectations.

Rating for Criterion I.D. Unit Coherence: Extensive

(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that lessons fit together coherently to target a set of performance expectations because student questions drive the lessons and students regularly revisit their original questions while also having the opportunity to develop new questions. Guidance is provided to support the cultivation of new questions that arise from related lesson-level phenomena.

Students revisit the initial phenomenon in order to revise and develop explanations:

- Lesson 1: Students make initial models, the class generates a Driving Questions Board (DBQ) that includes what students notice, wonder, identify as related phenomena, and ideas they have for future investigations. They also create a consensus model divided into three parts: the speaker (source), the arrow in the middle (medium), and the window (detector). A driving question for the entire board is identified "How can we detect sound from a distance?" (Teacher Edition, page 48)
- Students revisit and add to the DBQ throughout the unit. "To effectively support coherence for students and to honor their ideas and contributions to the storyline, return often to their initial ideas from the DQB and their suggestions for investigations. Mark the question we are investigating next or the investigation we will do next with a sticky note that has a star of check mark on it. Emphasize to students that these ideas came from them" (Teacher Edition, page 59).
- The DBQ is purposely revisited in Lessons 2, 6, 7, 10, 12, and 14. Example, in Lesson 6 "Say let's visit our DQB and see which questions we have made progress and then later tomorrow we can see if there are any questions we need to refine or want to pursue in upcoming lessons" (Teacher Edition, page 149). For example, in Lesson 7 "Gather in a Scientists Circle around the DQB. Ask

students to bring their notebooks and display the Initial Class Consensus Model poster. Remind students where we are in our investigation" (Teacher Edition, page 167).

- Navigation to the Next Lesson sections are included in unit material. For example, in Lesson 12, "Navigation: Review the questions we still have about hearing loss to motivate the work we'll do next time comparing the energy transfer of higher-amplitude versus higher-frequency vibrations" (Teacher Edition, page 236).

Suggestions for Improvement

N/A - The unit materials included extensive evidence of unit coherence.

I.E. Multiple Science Domains: When appropriate, links are made across the science domains of life science, physical science and Earth and space science.

Disciplinary core ideas from different disciplines are used together to explain phenomena.

The usefulness of crosscutting concepts to make sense of phenomena or design solutions to problems across science domains is highlighted.

Rating for Criterion I.E. Multiple Science Domains: Adequate

(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that links are made across the science domains when appropriate because this unit focuses on the physical sciences domain and occasionally provides students with connections to the life sciences domain. The unit does not make connections to the Earth and Space Sciences domain, but students' DCI content knowledge of this domain is not necessary for figuring out the central phenomenon.

This unit combines elements from PS4A Wave Properties, PS3C Relationship between Energy and Forces with some connection to LS1.D Information Processing. Understanding of the following DCI elements are necessary to explain the phenomenon of "sound from a truck speaker causes a window to vibrate."

- PS4A Wave properties, element: *a simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.*
  - Lessons 1–6 explore vibrations produced by the sound source.
- PS4A Wave properties, element: *A sound wave needs a medium through which it is transmitted*
  - Lessons 7–11 build understanding of the medium through which sound travels.
- PS3C Relationship between energy and forces, element: *When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.*
  - In Lesson 13, "conduct an investigation to gather evidence about how the energy transferred by a sound source changes in relationship to the frequency and amplitude of the sound" (Teacher Edition, page 247).

- LS1.D Information Processing element: *Each sense receptor responds to different inputs transmitting them as signals ~~that travel along nerve cells~~ to the brain.*
    - In Lesson 2, students are assigned a reading, "*How do Insects Make Sounds?"*
    - In Lesson 12, students use information from various sources and understanding of how sound transfers to explain how the structures of the human ear function to allow this to happen.

Suggestions for Improvement

Consider ways for students to construct knowledge about the human ear by engaging in SEPs and applying CCCs. The life science domain of LSD.1 was primarily addressed through the use of videos and readings. For example, the unit could perhaps provide students with data from the same source but received by different human ears with varying responses (vibrations) of ear drums, such that students would need to apply knowledge of vibrations to analyze and interpret the data provided.

I.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.

Rating for Criterion I.F. Math and ELA: Adequate

(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that the materials provide grade-appropriate connections to mathematics, English language arts (ELA), history, social studies, or technical standards because grade appropriate math and ELA are purposefully incorporated into lessons and there is teacher support to help students make sense of the connections. Reading material goes beyond the textbook, writing assignments are varied in structure and purpose and students have multiple opportunities for discourse in a variety of formats.

The materials include many grade-appropriate connections to ELA and mathematics, including:

- The "What are prerequisite math concepts necessary for this unit?" section details prior math skills required for this unit along with the specific Math Common Core Standards that are utilized in the unit (Teacher Edition pages 15–16).
- The "Supporting Students in Making Connections in Math" section found in Lessons 4, 5, and 13 point out specific connections to the Math CCSS in this unit. Lesson 4, "In this lesson, students analyze patterns in graphical representations of the stick's motion in order to figure out that a sound-maker moves further back and forth (has a greater amplitude) for louder sounds" (Teacher Edition page 121).
- The "Supporting Students in Making Connections in ELA" section found in Lessons 1, 2, 3, 4, 6, 8, 12 and 13 points out the specific connections to the ELA CCSS in this unit. Lesson 1, "Today's activities rely on students communicating and articulating their thinking. One tool that may

support this classroom discussion is the Communicating in Scientific Ways sentence starters" (Teacher Edition page 40).

- Reading material goes beyond the textbook. In Lesson 12, students use a reading and tone generator data to figure out what animal (elephant, human, dog) can hear the lowest and highest frequencies. Then students read information summarized from interviews with experts on human hearing.
- Writing assignments are varied in structure and purpose. In Lesson 1, students set up a notebook and teachers are provided with "helpful hints for keeping the notebooks organized" (Teacher Edition, page 38). In Lesson 4, provided with a position vs. time graph for a harp string, students answer a series of questions including "describe in words what you would see the actual harp string doing differently if it were producing the same pitch but louder" (Harp String Graph Handout, page 1). In Lesson 10, Students work in groups to complete an analogy map for "visualizing sound in a medium" simulation (Analogy Map Handout, page 1).
- Students have multiple opportunities for high-level verbal discourse in a variety of formats and scenarios (partners, small group, and full class).
    - Built into the lesson format are Building Understandings Discussions that provide teachers with question prompts for guiding student discourse.
    - Students often work in pairs. In Lesson 6, students work in pairs and then share findings with another pair (Lesson 6, slides C–D). In Lesson 9, students work in pairs to develop state of matter models (Teacher Guide, page 191).
    - Students gather in Scientist Circles around the DQB to have whole-group discussions (Lessons 1, 2, 6, 8, 10, and 13). In Lesson 13, "students gather in a Scientist Circle to come to consensus about how changing the amplitude and frequency of vibrations changes how much energy is transferred" (Teacher Edition, page 248).
    - Students provide support to others and through discourse elicit additional ideas, which students build upon to develop a deeper understanding. For example:
        - In Lesson 1, students "convene in a Scientists Circle to construct a class consensus model for the truck-window phenomenon using their models and their observations of the video and the speaker" (Teacher Edition, page 30).
        - In Lesson 8, "During a consensus discussion, students can practice talking with each other as a community of learners. Engaging in this practice can support all learners in developing academic discourse. They listen to each other's ideas and findings, ask questions about evidence, and come to agreement about what the class figured out in an investigation" (Teacher Edition, page 183).

Suggestions for Improvement

The unit materials included many grade-appropriate connections to mathematics and English language arts (ELA). It may also be helpful to consider connections to history, social studies, or technical standards, such as the history of hearing aid design.

How Can Sound Make Something Move?
EQuIP Rubric for Science Evaluation

Overall Category I Score (0, 1, 2, 3): 2

Unit Scoring Guide – 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)

Category II. NGSS Instructional Supports

Score: 3

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*

II.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.

Students experience phenomena or design problems as directly as possible (firsthand or through media representations).

Includes suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate.

Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience.

Rating for Criterion II.A. Relevance and Authenticity: Adequate

(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world because students experience the phenomena firsthand (video, investigations, simulations) and these firsthand experiences serve as the onramps to understanding. Materials provide support to teachers to help all students make connections to their own lives. These connections provide motivation for students to engage in the learning.

Examples of students experiencing phenomena as directly as possible to generate compelling lines of inquiry that come from their experience include:

- In Lesson 1, all students experience the anchor phenomenon by watching a video of the event.
- Most lessons involve students participating in investigations of related phenomena that help address sense-making. In Lesson 3, students use a laser-mirror apparatus to experience vibration of solid objects and generate claims based upon the evidence gathered. In Lessons 4 and 5, students collect data using a motion detector and stick apparatus to create and analyze motion graphs.

Examples of material to support teachers in helping students make connections to their own lives include:

- Initial Ideas for Investigation poster: “create an Initial Ideas for Investigation poster and record the students’ thoughts on how we can figure out the answers to our initial questions as we move forward” (Teacher Edition, page 30).
- Giving students time to explain their connection to a specific instrument may help them (or other students) engage with the work the class is doing and may provide insight for the class about the

cultural connections that people make with different modes of music and different instruments" (Teacher Edition, page 60).

Suggestions for Improvement

Consider providing opportunities for and the expectation that students look for and apply learning to situations outside of the classroom.

II.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.

Rating for Criterion II.B. Student Ideas: Extensive

(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that the materials provide students with opportunities to both share their ideas and thinking and respond to feedback on their ideas because the teacher is supported as the expert facilitator, drawing out student ideas while coordinating forward movement toward targeted learning.

The unit materials provide support to teachers for eliciting students ideas and helping them to generate and respond to feedback:

- Throughout the unit, students participate in classroom consensus-building discussions designed to connect key findings from the day's activities with on-going, sense-making of the central phenomenon. "Students work on the three sections of the Progress Tracker after important punchlines in the unit are figured out as a class, usually after the class comes to consensus about something. We suggest not skipping these consensus moments with the Progress Tracker. If these sections are missing, students may have trouble moving forward in their sensemaking" (Teacher Edition, page 67).
- Teachers are provided with guidance for the facilitation of peer feedback "there will be times in your classroom when facilitating students to give each other feedback will be very valuable for their three-dimensional learning and for learning to give and receive feedback from others. We suggest that peer review happen at least two times per unit" (Teacher Edition, page 19). "You could also have students give and get feedback using sticky notes instead of verbal feedback. Prompts for what to write include the following: I wonder about..., I noticed you..., I appreciate how you..., It would be clearer if you added..., I see you're thinking about..., Do you think you should add...." (Teacher Edition, page 67)

Students have opportunities to share ideas and feedback with each other directly. Students are provided opportunities to then utilize that feedback to construct new learning. Feedback is based on student performance.

- "You could also have students give and get feedback using sticky notes instead of verbal feedback. Prompts for what to write include the following…" (Teacher Edition, page 67).
- In Lesson 7, "Once students have had a few minutes to write feedback on their partners' initial models, have students switch their models back to their original authors. Once students have their initial models, instruct them to use the feedback their partner provided to complete the questions on *Lesson 7 Exit Ticket* As students are working, walk around and look at the feedback students provided to their peers to see if they are providing specific and actionable feedback" (Teacher Edition, page 172).

Suggestions for Improvement

- Consider opportunities to have students reflect on and clarify the limitations of their investigations.
- Consider additional opportunities where students can reflect on and explain *why* they incorporated the new ideas that they generated during classroom discussions into their models as well as how these ideas that changed their own thinking.

II.C. Building Progressions: Identifies and builds on students' prior learning in all three dimensions, including providing the following support to teachers:
Explicitly identifying prior student learning expected for all three dimensions
Clearly explaining how the prior learning will be built upon.

Rating for Criterion II.C. Building Progressions: Adequate

(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials identify and build on students' prior learning in all three dimensions because clear guidance is provided for teachers to help build on students' levels of proficiency. Unit materials are designed to build upon the typical level of proficiency students at this grade level have with each of the three dimensions.

Materials identify prior learning in each of the three dimensions:

- The teacher material includes "What should my students know from earlier grades and earlier middle school units." It lists the DCIs, SEPs, and CCCs and the grade-level expectations for each. (Teacher Edition pages 12–15)
- The "Where are we going (and NOT going)" section at the beginning of each unit outlines key background knowledge that is required as well as what the lesson addresses and does not address, but only for the DCIs—not the CCCs or SEPs.
- The teacher material includes "What are some common ideas students might have." It provides teachers with expected prior learning and delineates some common student misconceptions. (Teacher Edition page 15)

- The material includes adaptations for students are below the expected level of proficiency. In Lesson 7, "If students haven't developed lines of evidence from previous grades (PS1 in grade 5) that air is matter and therefore air has mass, you may need to conduct these additional investigations first. A quick demonstration would be to mass a soda bottle before opening it. Then ask students what will happen when the bottle cap is opened and why. And then remass the bottle and cap after opening it (the mass will decrease because some of the gas escapes upon opening). Another suggestion is to test an inflated volleyball. Mass it and then pump it up a little bit more, and mass it again. In both cases, you may need to use a piece of tape to keep the item on the scale. If so, use the same piece of tape throughout the massing." (Teacher Edition, page 170) Lesson 9, "Students have previously explored the particulate nature and behavior of matter. In 6.2 Thermal energy, students experienced particles moving and colliding differently depending on temperature. In, 6.3 Weather students explored the particles in solids, liquids, and gases moving and transferring energy. In 7.1 Chemical reactions, students saw that matter is made up of pieces that can be rearranged. If students haven't developed sources of evidence from previous grades that solids, liquids, and gases are made of particles and that the spacing between those particles is different for a solid and liquid versus a gas, and that the particles in liquid or gas can move, you may need to add additional supplemental lessons before this one." (Teacher Edition, page 193)

Suggestions for Improvement

- It would be extremely helpful to add CCCs and SEPs to the Where are We going and not going section of the Teacher's guide.
- Consider including material to guide teachers in making adaptations, in each of the three dimensions, for students who are above the expected level of proficiency.

II.D. Scientific Accuracy: Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning.

Rating for Criterion II.D. Scientific Accuracy: Extensive

(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that the materials use scientifically-accurate and grade-appropriate scientific information because the science vocabulary, concepts and representations are accurate, and information is provided to support teachers when students have ideas contrary to the accepted ones.

There is strong support for teachers to clarify potential alternative conceptions that they or their students might have. For example:

- Lesson outlines include "Where We Are Going" and "Where We are NOT Going" sections, which include opportunities to address potential misconceptions. "We hope to foreground competing

explanations in this lesson to motivate ideas for investigations that correspond to the investigations students will do in the first learning set of the unit" (Teacher Edition, page 40).

- Teacher material includes "What are some common ideas students might have?" "We have also seen evidence that some students remain committed to a science idea commonly developed in prior grades that solids keep their shape (as opposed to liquids taking the shape of their container). So they may resist accepting the claim that things like a table, the floor, or the wall deform, spring back, and overshoot (very slightly). Students need a line of evidence to help them make sense of and accept this idea, which is what the laser and mirror investigation in lesson 3 provides" (Teacher Edition, page 15).
- "Using words like bend, deform, springy, or elastic will help set up the next lesson, which is motivated by the question of whether all objects bend or deform or are springy (up to a point). Use the scientific word deform in concert with the phrase 'or bend' and use the word elastic with the phrase 'or springy' in future discussions to help build familiarity with the idea that both terms, in each case, are expressing the same idea" (Teacher Edition, page 67).
- In Lesson 8, "Students may think that the reason we can hear through water is because water has air in it. While much water (e.g., in fish tanks and ponds) has dissolved gas in it, we want to convince students that sound can travel through a liquid. Consider using vegetable oil as another liquid if this idea comes up" (Teacher Edition, page 182).

Suggestions for Improvement

N/A - The unit materials included extensive evidence of scientific accuracy.

II.E. Differentiated Instruction: Provides guidance for teachers to support differentiated instruction by including:

Appropriate reading, writing, listening, and/or speaking alternatives (e.g., translations, picture support, graphic organizers, etc.) for students who are English language learners, have special needs, or read well below the grade level.

Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations.

Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts.

Rating for Criterion II.E. Differentiated Instruction: Adequate

(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials provide guidance for teachers to support differentiated instruction because unit materials provide multiple differentiation strategies with examples and guidance that support reading, writing, listening, and/or speaking that are integral to sense-making and result in the whole lesson being accessible for all students.

Extra support for students struggling to meet performance expectations includes:

- Teacher material includes a *Prerequisite Math Concepts Necessary for the Unit section* which includes some differentiation support such as "Depending on the math understanding that students display in Lessons 4 and 5, students might need support in reading and interpreting these graphs. It may help some students to go over the axes of the graph as a class to draw attention to what the graph is showing and the students may benefit from probing questions like 'What differences do you notice between these graphs? How do those differences compare to what we saw in the graphs we made with the motion detector?'" (Teacher Edition, pages 15–16)
- Teachers are advised that one of the readings in Lesson 3 is at the 1200–1300 Lexile and that they "might want to provide students with extra support such as reading the article aloud to them, or allowing them to read it to a partner" (Teacher Edition, page 98).
- Teacher material includes an *Assessment System Overview* section which includes some differentiation support such as "If student… lacks words to explain what is going on in the picture, consider asking that student tell you aloud about the model while you scribe captions to explain thinking" (Teacher Edition, page 18).
- Teacher material includes *Supporting Students in Making Connections in ELA* sections which included differentiation support such as "Struggling students may benefit from a scaffolded reading of this text in a small group where the teacher guides students to read each paragraph aloud, drawing connections explicitly and visually to what is listed in the data table." (Teacher Edition, page 122) and "You may need to support students as they write about their thinking by encouraging them to use precise language that specifies what they observed in class and how that's the same or different from how the Big Ben and Moon investigations used lasers to detect motion, too" (Teacher Edition, page 95).

Extra support for English Learners includes:

- Teacher material includes *Attending to Equity* sections, which include differentiation support such as "Also, students may write in a language other than English if they choose and include images to accompany writing" (page 113) and to post a digital version of the reading "so that they can click the links in the reading to access the videos and explore the websites at their own pace while reading independently" (Teacher Edition, page 237).
- "When developing new vocabulary, strategies that may benefit emergent language learners are to use student-friendly definitions, make connections to cognate words when possible, and include a visual representation of the word" (Teacher Edition, page 66).

Extra support for upper level learners includes:

- "Please be aware that the article about Big Ben is Lexile level approximately 1200-1300, which is higher than the expected complexity for eighth grade independent reading. So, you may want to provide students with extra support, such as reading the article aloud to them, or allowing them

to read it with a partner. Alternately, this article provides a differentiation opportunity for higher readers who are ready for that challenge themselves" (Teacher Edition, page 95).

- In Lesson 12, "Assign your students *Hearing in Elephants, Dogs, and Humans* as home learning, or as an in-class extension of today's work. Be aware that the Lexile level for this article is approximately 1200-1300, which is higher than the level expected for eighth grade independent reading. You may want to provide additional support to your students by reading it aloud to them or having them read with a partner. Or, you could reserve this article for higher-level readers in your class as a differentiation opportunity" (Teacher Edition, page 243).

Suggestions for Improvement

- Consider including additional differentiation opportunities for high-achieving students. For example, In Lesson 12, consider challenging high-achieving students by asking them to determine how the ear functions after watching the ENT video and receiving the diagram of the component structures of the ear. Students can then check their thinking by comparing their models with students who did the extra readings.
- Consider including an extension opportunity for students who have mastered the lesson level PEs. For example, an engineering design activity, designing an instrument or a solution to a need related to sound, structured around Engineering Design elements.
- Include additional strategies to support for English Language Learners.

II.F. Teacher Support for Unit Coherence: Supports teachers in facilitating coherent student learning experiences over time by:

Providing strategies for linking student engagement across lessons (e.g. cultivating new student questions at the end of a lesson in a way that leads to future lessons, helping students connect related problems and phenomena across lessons, etc.).

Providing strategies for ensuring student sense-making and/or problem-solving is linked to learning in all three dimensions.

Rating for Criterion II.F. Teacher Support for Unit Coherence: Extensive

(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that the materials support teachers in facilitating coherent student learning experiences over time because students have an opportunity to engage in asking questions about phenomena that they feel they need to address in upcoming lessons, and future investigations are focused on answering these student-generated questions.

The phenomena and questions drive the learning across lessons. Students routinely cultivate new questions at the end of a lesson that lead to future investigations. Examples include:

- The Driving Question Board (DBQ) is utilized throughout the unit to cultivate and revisit student questions. In Lesson 2, the question "do all objects vibrate when they make sounds?" is added to the DQB and becomes the focus of Lesson 3.
- Teacher materials include *Navigation* sections which include coherence support such as "Recall ideas for investigating the sound source and discuss ideas for how instruments and speakers make different sounds" (Teacher Edition, page 56).
- The *Progress Tracker* is used routinely and helps students to connect phenomena, questions and learning across the lessons. "The Individual Progress Tracker is a tool to help students reflect on their own learning in response to the question being investigated. Encourage students to use this space to share as many new connections they have made, but also to note where they are still confused" (Teacher Edition, page 136).

In addition, teachers are supported to ensure that student sensemaking is linked to learning for DCIs, CCCs, and SEPs. For example:

- The list of "What are some common ideas students might have?" includes reminders such as "Remember not to assume from words or representations in students' models that they have an understanding of how sound works on a deep, mechanistic level. It is highly unlikely at the beginning of the unit that students are thinking of the sound waves as emergent phenomena that are a result of many particles of matter interacting with each other in a repeating pattern. It is far more likely that they heard about sound being a wave, or read about it, or have seen an icon on their stereos or phones that is a wave-like representation" (Teacher Edition, page 15).
- The Strategies for Initial Discussion Suggestions "With these priorities in mind, we do want students to begin transitioning to thinking about what's happening to cause the patterns they noticed in the video. Supporting students in being specific and thoughtful about what they observed (and what questions those observations make them ask) will help drive the class towards a need to investigate what's happening on a deeper level" (Teacher Edition, page 40). "The purpose of this discussion is simply to get the students to articulate parts of the model that may be in their heads but not on paper. Don't evaluate whether the elements should or shouldn't be there. Just help them talk out loud about everything that is in the model, and if they say something that isn't clearly shown in the model, push them to say where in the model it appears or what they would change or add to the model to show that idea" (Teacher Edition, page 44).

Suggestions for Improvement

N/A - The unit materials included extensive evidence of teacher support for unit coherence.

II.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.

Rating for Criterion II.G. Scaffolded Differentiation Over Time: Adequate

(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials support teachers in helping students engage in the practices as needed and gradually adjusts supports over time because supports are provided for all students to engage in the SEPs in ways that not only integrate the other two dimensions, but also explicitly build student understanding and proficiency in the SEPs over the course of the unit.

Instructional materials create learning experiences targeting students with diverse needs and abilities, so they can connect to and use to make progress over time toward common learning goals of engaging in the practices and making sense of phenomena. For example:

- Sidebars in the Teacher Edition provide teacher guidance with the SEPs. These sidebars direct teachers how to adjust lessons to specifically engage students in the practices. For example:
    - In Lesson 3, *Supporting Students in Engaging in Argument from Evidence* "Considering possible outcomes directly connects to the reasoning students will do based on data from this investigation. So, thinking through the possible outcomes is time well spent to prepare students for reasoning later on" (Teacher Edition, page 88).
    - In Lesson 3, "Supporting Students in Engaging in Argument from Evidence: In this lesson, students fill out a table to support their argument about a claim based on evidence and may have some guidance about their reasoning. In future lessons, this table structure can be gradually removed as students become more independent in writing a claim based on evidence and reasoning" (Teacher Edition, page 90).
- Students develop arguments with some scaffolding at the beginning of the unit and independently later in the unit (Teacher Edition, page 13).

Suggestions for Improvement

- Consider additional methods for adjusting support in response to individual student progress in each of the dimensions. For example, a step-by-step tool to help students who struggle identifying patterns in data could be replaced by prompts and then removed altogether in response to student progress.
- It would be very helpful to ensure that scaffolding in the unit builds *on* elementary-level use of SEPs and *toward* middle school use. Currently, the unit often scaffolds students to build their proficiency *toward* elementary-level use of SEPs.

Overall Category II Score (0, 1, 2, 3): 3

How Can Sound Make Something Move?
EQuIP Rubric for Science Evaluation

Unit Scoring Guide – 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

Category III. Monitoring NGSS Student Progress

Score: 3

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*

III.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.

Rating for Criterion III.A. Monitoring 3D Student Performances: Adequate

(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials elicit direct, observable evidence of students using practices with core ideas and crosscutting concepts to make sense of phenomena and/or design solutions because tasks are driven by well-crafted phenomena that are able to elicit rich student performances.

Tasks routinely and comprehensively provide students with opportunities to make their thinking visible with some variation in opportunities and purposes. For example:

- Teacher material includes a *Lesson-by-Lesson Assessment Opportunities* section which includes opportunities for students to make their thinking visible. "The table below summarizes opportunities in each lesson for assessing every lesson-level performance expectation (LLPE). Examples of these opportunities include student handouts, home learning assignments, progress trackers, or student discussions. Most LLPEs are recommended as potential formative assessments. Assessing every LLPE listed can be logistically difficult. Strategically picking which LLPEs to assess and how to provide timely and informative feedback to students on their progress toward meeting these is left to the teacher's discretion" (Teacher Edition, page 19).
- In Lesson 6, the Midpoint Assessment Rubric addresses DCIs and CCCs (Teacher Edition, page 155).
- In Lesson 11, students create individual models for assessment, and a Modeling Rubric is provided to assess the three-dimensional aspects of the model. (Teacher Edition, page 233)

Suggestions for Improvement

Consider more variety in the opportunities students are given to make thinking visible. For example, variation in models or application to unique but related phenomena (these could be the list generated during Lesson 1).

III.B. Formative: Embeds formative assessment processes throughout that evaluate student learning to inform instruction.

Rating for Criterion III.B. Formative: Adequate

(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials embed formative assessment processes throughout that evaluate student learning and inform instruction because the materials include many regular opportunities for formative assessment with explicit supports for the formative assessment process.

Formative assessment opportunities occur multiple times within each lesson. These are accompanied by clear guidance for how to interpret a range of student responses and change instruction based upon the varied responses. For example:

- In Lesson 4, "If students are able to correctly explain the different patterns for louder versus softer sounds, but they do not use the terms 'amplitude' or 'frequency' (or don't use them correctly) to describe them., consider having them complete Harp String Graph Handout with a partner" (Teacher Edition, page 21)
- In Lesson 5, "While students are working in their groups, take the opportunity to formatively assess their understanding of frequency and amplitude. Students are calculating the amplitude as a review from lesson 4 but also to show that it is frequency that is changing with the length of the stick and not amplitude. Look for students to notice that the changes in amplitude are the same for both the high and low pitch graphs but the frequency of vibrations is more for the high pitch sound and the short stick. To support students in calculating the amplitude and frequency, refer them to the graphs they annotated in Lesson 4 and to the class definitions on the word wall" (Teacher Edition, page 133).
- In Lesson 6, "*Connecting Graphical Representations to the Sounds Made* provides a great opportunity for students to gain further practice in constructing an argument using evidence from graphs to support an explanation for which patterns of frequency and amplitude of a wave are related to sounds that we can hear. This practice contains scaffolding for the elements of their argument and can provide some just in time formative information before the independent assessment they take on day 2 of this lesson. If students struggle supporting their claims with evidence have them look back to the data they collected in Lessons 4, 5, and 6 or their progress trackers" (Teacher Edition, page 148).
- In Lesson 9, "If students are not able to show the particle movement in their models ask them to simulate what happened in the simulation with their bodies using their hands as particles. If students do not readily talk about what is happening with the particles in terms of collisions and energy transfer, refer them back to their original vibration model in lesson 2 where they indicated that the energy was transferred to the object when the force was applied" (Teacher Edition, page 24).

- In Lesson 11, "Clearly, this model is a critical assessment of whether students have put together the pieces of this unit so far and are able to explain them in words and pictures. The students have their Gotta-Have-It Checklist to use as a guide for modeling, but you should use the *Lesson 11 Modeling Rubric* to evaluate each student's model and provide timely feedback about what they're doing well and what they may still be missing" (Teacher Guide, page 228).

Suggestions for Improvement

The current formative assessment processes in the unit are generic and do not call out aspects of student responses that might be tied to equity and access. Progression rubrics with explicit measures of progress, based upon the elemental level of each of the three dimensions and associated interventions would be helpful.

III.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.

Rating for Criterion III.C. Scoring Guidance: Adequate

(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials include aligned rubrics and scoring guidelines that help the teacher interpret student performance for all three dimensions because clear guidance is provided for teachers to interpret student progress, in relation to both the instructional materials as well as the targeted standards.

Scoring guidelines include rubrics, answer keys, a range of possible student responses, and teacher guidance for scoring and interpretation. For example:

- A *Rubric for Modeling Motion of an Object Making Sounds* is included to "provide feedback to students as they explain the components and interactions involved when an object makes sounds." The modeling (SEP) rubric includes statements related to patterns, structures, and cause and effect (CCCs), related to sound (DCI) (Teacher Edition, page 79).
- The mid-unit assessments require students to make a model (SEP) and make claims from evidence (SEP) based on patterns observed in graphs (CCC) about motion detector data (DCI). A key is provided and includes a scoring guide (pages 153–162).
- Scoring Rubrics are provided throughout the unit. For example: Lesson 2 - Rubric for Modeling Motion of an Object Making Sounds, Lesson 6 - Rubric for Modeling Motion of an Object Making Sounds (Revisited), Lesson 11 - Modeling Rubric, Lesson 14 - How can we explain our anchoring phenomenon, and which of our questions can we now answer?
- Teacher materials include *Teacher Reference* documents that include rubrics, sample student answers, and answer keys. For example: Lesson 2 - Instrument and Speaker Stations, Lesson 3 - How do Objects Move When They Make Sounds, Lesson 6 - Assessment Key, Lesson 11 - Gotta

Have It Checklist Key, Lesson 12 - Activity Sheet Suggested Responses, Lesson 13 - Example Class Data Table for Energy Transfer for Amplitude and Frequency Investigation, Lesson 14 - Gotta Have It Checklist Key

Suggestions for Improvement

Consider including specific assessment targets focused on the elemental level of each of the three dimensions. Progression rubrics that assess student growth in targeted element would provide information necessary for interpreting progress and need for additional resources.

III.D. Unbiased tasks/items: Assesses student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.

Rating for Criterion III.D. Unbiased Task/Items: Adequate

(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples because vocabulary (science and non-science) is grade level appropriate and the amount of text in tasks/items is grade appropriate and representations or scenarios provided in the unit are culturally neutral.

Accessible and unbiased methods for representations and vocabulary include:

- The Student Edition includes lesson-by-lesson directions including Navigation information, icons that represent when students should turn and talk, write in notebook, share with class, work in a group, or work individually.
- The steps that need to be followed for each lesson are numbered sequentially in the Student Edition that accompanies this unit.
- PowerPoint slides include directions for students to follow and use the same icons as the student edition, e.g., a 'write in notebook' icon with directions "Make a T-chart in your science notebook and record your noticing and wonderings" (SO.L1 Slides.pptx).
- The use of a word wall in the unit helps make scientific vocabulary accessible to all students.

Suggestions for Improvement

- Consider guiding teachers to think about the limitations of the scenario in reaching all students. For example, the unit could include an emphasis on the need and importance of using a speaker in the classroom for students unfamiliar with a truck speaker or vibrations created by a speaker.
- Consider including a wider variety of ways for students to convey understanding. For example: talking about their learning, creating visual representations, or writing short and more complex answers.

III.E. Coherent Assessment system: Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.

Rating for Criterion III.E. Coherent Assessment System: Extensive

(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning because the assessments are clearly mapped to three-dimensional learning goals and require students to apply appropriate elements of the three dimensions to make sense of the same learning goals in a variety of ways.

Assessments are designed to connect to the learning goals and apply appropriate elements to make sense of the central phenomenon. For example:

- In the *Assessment System Overview*, types of assessments available in the unit are provided along with their purpose, three-dimensional focus, and accompanying scoring guidance (Teacher Edition, pages 17–19).
- "The student work in Lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn where students are coming in and what ideas they have that you can build on in this unit. The more ideas in your classroom the better" (Teacher Edition, page 17).
- "The Driving Question Board is another opportunity for pre-assessment. You can see the types of questions your students are asking and what they are asking about" (Teacher Edition, page 17).
- In Lesson 6, "This midpoint assessment is important formatively to make sure the class is on the same page and ready to move forward in the unit" (Teacher Edition, page 18).
- "The student self-assessment discussion rubric can be used any time after a discussion to help students reflect on their participation in the class that day" (Teacher Edition, page 19). In Lesson 4, "This is a great opportunity for students to self-assess themselves on their engagement in classroom discussions" (Teacher Edition, page 118).
- "This lesson includes a transfer task to give students an opportunity to use the 3 dimensions to make sense of a different phenomenon. This is meant to be a summative assessment task for the unit and it gives you a grading opportunity" (Teacher Edition, page 19).

Suggestions for Improvement

Consider including a greater variety of methods for assessing student progress toward learning goals. For example, performance tasks and portfolios could be added.

III.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

Rating for Criterion III.F. Opportunity to learn: Extensive

(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that the materials provide multiple opportunities for students to demonstrate performance of practices connected with their understanding of core ideas and crosscutting concepts because students engage in multiple three-dimensional performances that are opportunities for them to demonstrate learning over the course of the unit and receive feedback on what they learned. Students utilize multi-modal feedback across a series of student performances to demonstrate new thinking based on peer and teacher feedback and personal reflection.

The multiple, interconnected opportunities for learning over time along with multi-modal feedback loops include:

- Teachers are provided with a guide for Peer Feedback facilitation. "There will be times in your classroom when facilitating students to give each other feedback will be very valuable for their three-dimensional learning and for learning to give and receive feedback from others. We suggest that peer review happen at least two times per unit." (Teacher Edition, page 19)
- In Lesson 1, after watching the truck video, students discuss observations with a partner, then with the class, they write a class record of observations and draw, share, and analyze a model.
- In Lesson 2, a scoring rubric is provided for *Modeling Motion of an Object Making Sound* which provides opportunity for individual, written feedback from the teacher.
- In Lesson 5, "Collect this Exit Ticket at the end of class or at start of the next class. This will give you a day or two before the individual assessment at the end of the next lesson to provide feedback to students to help guide their understanding and revisions before that assessment." (Teacher Edition, page 137)
- In Lesson 7, "Once students have had a few minutes to write feedback on their partners' initial models, have students switch their models back to their original authors. Once students have their initial models, instruct them to use the feedback their partner provided to complete the questions on *Lesson 7 Exit Ticket.* As students are working, walk around and look at the feedback students provided to their peers to see if they are providing specific and actionable feedback" (Teacher Edition, page 172).

Suggestions for Improvement

It would be helpful to ensure that students have multiple opportunities to demonstrate their understanding of all targeted elements of all three dimensions. Currently, some targeted elements are not used in the unit.

Overall Category III Score (0, 1, 2, 3): 3

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 Score

Category I: NGSS 3D Design Score (0, 1, 2, 3): 2
Category II: NGSS Instructional Supports Score (0, 1, 2, 3): 3
Category III: Monitoring NGSS Student Progress Score (0, 1, 2, 3): 3
Total Score: 8
Overall Score (E, E/I, R, N): E

Scoring Guides for Each Category
Unit Scoring Guide
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)
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
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 Scoring Guide
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)*