

How can a magnet move another object without touching it?

EQIP Rubric for Science Evaluation

Developer/Curriculum: OpenSciEd

Unit Name: Forces at a Distance

Grade: Middle School

Date of Review: December 2019

Overall Rating (N, R, E/I, E): E

Category I: NGSS 3D Design Score (0, 1, 2, 3): 3

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): 9

[Click here to see scoring guidelines](#)

This review was conducted by the [Achieve](#) using the [EQIP 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	Extensive	A. Monitoring 3D Student Performances	Extensive
B. Three Dimensions	Extensive	B. Student Ideas	Extensive	B. Formative	Extensive
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	Extensive	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. It is obvious that this unit was thoughtfully crafted, and it has many strengths, including the use of a strong anchoring phenomenon that drives learning, an emphasis on the development of the students' use of the CCC of Cause and Effect, providing multiple ways for students to express their understanding, a thorough assessment system, and the use of home learning to connect new science ideas with the real lives of students.

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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: **3**

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**

The reviewers found extensive evidence that learning in this unit is driven by students making sense of a phenomenon. Students work to make sense of how a speaker functions. In a previous unit they developed an understanding of the relationship between sound and vibration of matter, but to more fully understand how the speaker works, they need to make sense of what causes the speaker to vibrate. Students are motivated to figure out the phenomenon because music is something young people can connect to easily. In order to motivate students to figure out the related phenomena, students have many opportunities to ask questions and connect their prior experiences with magnets and forces. Students regularly return to the phenomenon to add layers of explanation based on the evidence they gather. Throughout the unit, lessons are driven by new observations and questions developed from previous lessons that drive students learning to the next lesson.

The following examples are strong evidence of this criterion:

- The Anchoring Phenomenon Routine, explained on pages 12–14 of the Teacher Handbook, expresses the developers’ strategy of using a phenomenon to drive student learning through the unit. This strategy appears in lessons throughout the unit.
- The materials are organized so that students make sense of how forces cause a speaker to function and students regularly return to this phenomenon to add layers of complexity across the unit.
 - In Lesson 1, students are provided with an opportunity to discuss any experiences they

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have with speakers. The phenomenon is relevant and engaging. Students directly engage in the phenomenon by observing a dissected speaker and building a homemade speaker using a magnet, wire, and a plastic cup to play music. Students create a “I Wonder/I Notice” chart and share their observations (page 39, Teacher Edition).

- Students identify similar phenomena based on their own experiences in Lesson 1, page 50 (TE). They brainstorm examples of other objects that use magnets or wires to make the object or part of the object move.
- Students write questions about the phenomenon and those questions are organized on a Driving Question Board (Lesson 1, pages 52–55, TE). The developers use a unique way of organizing questions by having students place questions on a class-developed initial model. Students determine placement of the questions by thinking about where the question fits into the system portrayed in the initial model.
- The unit includes a section called Navigation at the end of each lesson (an example is on page 76, Lesson 2, TE). Learning is summarized and then additional student questions and ideas are used to transition to the next unit.
- In Lesson 6 (page 146, TE), students develop models to capture the cause and effect relationships regarding the speaker system that they have already figured out (e.g., flipping one of the two magnets so that the poles are alike or the poles are opposite will change the shape of the magnetic field) and they then use the models to identify what they still need to figure out (e.g., where the energy comes from) to understand how the speaker works.

Suggestions for Improvement

N/A

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: **Extensive**

The reviewers found extensive evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions. Crosscutting Concepts, Science and Engineering Practices, and Disciplinary Core Ideas are all utilized and developed at a grade-appropriate level in service of making sense of phenomena.

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Science and Engineering Practices (SEPs): *Extensive*

The reviewers found extensive evidence that students have the opportunity to use and develop the SEPs in this unit. The following examples are strong evidence where students are developing and using Science and Engineering Practices:

Asking Questions and Defining Problems

Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.

- Students begin by generating questions about a phenomenon. (Lesson 1) Throughout the unit, students use additional observations and results to refine those questions, changing some to reflect cause and effect relationships and changing others into testable questions.
 - Lesson 1 provides multiple opportunities for students to ask questions after viewing a video of a speaker (TE, page 39) and after discussing the parts of the speaker (TE, page 47).
 - In Lesson 1, students ask questions about the cause-and-effect relationship of the home-made speaker they built. Additional guidance is given by referencing the *Framework* and clarifying the difference between asking questions, making predictions, and framing hypotheses (TE, page 52). Students create an "Idea of Investigation" poster after building a Driving Question Board as a class (page 56, TE).
 - Additional student questions arise and are recorded as students view a demonstration of iron filings around a magnet (TE, pages 102–103).

Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.

- In Lesson 4, page 105 (TE), students generate new questions that arise from their investigation of magnetic fields. Answers to these questions will help students to further modify their initial model.

Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.

- After generating questions about the phenomenon, students discuss which of the questions could lead to authentic classroom investigations (Lesson 1, page 56, TE).

Developing and Using Models

Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.

- Students use new evidence and understandings to create increasingly sophisticated models.
 - Lesson 1, page 46 (TE), has students create models of both the store-bought and homemade speakers to compare and discern what elements of the speaker are essential.

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- In Lesson 1, page 49 (TE), students work in a Scientist Circle to develop an initial consensus model.
- In Lesson 6, page 147 (TE), students use results from an investigation to add to and revise their model in small groups and then using a Scientist Circle to form a consensus model. The model includes parts that are not observable like the cause of the force and what is happening in the space between the coil of wire and the magnet.

Develop or modify a model—based on evidence—to match what happens if a variable or component of a system is changed.

- In Lesson 6, page 145 (TE), the class creates a list of all the changes they have made to the speaker system through the unit as well as the effects of those changes and mechanisms underlying the effect. They are then asked to use this list to, “Refine a model of the [speaker] system that captures what we have figured out about cause-and-effect relationships” (Lesson 6, Slide E). The example class consensus model students then make (page 149, TE) includes how the system operated when components are changed (e.g., magnets flipped to have like poles together) and the general sources of evidence that support the model.

Develop a model to describe unobservable mechanisms.

- The whole class develops a consensus model that includes a description of the unobservable mechanisms in a system of a magnet and a coil of wire (Lesson 6, pages 147–148, TE). These unobservable mechanisms include the force between the coil of wire and the magnet and the magnetic field.

Planning and Carrying Out Investigations

Plan 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.

- Throughout the unit, students assume increasing responsibility to develop investigation plans that control variables and accurately produce data.
 - The class engages in a discussion of independent and dependent variables as they plan an investigation (Lesson 3, pages 88–89, TE).
 - Students investigate what would happen to the cart when released from the magnet. Students determine what conditions they want to test and how many trials they want to run for each condition (Lesson 7, Slide E).

Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

- In Lesson 2, page 68 (TE), students collect data to establish that magnets interact with certain objects and that the paired forces either attract or repel. They are then asked to answer scientific questions such as: “Is there a force on the magnet from the coil? How do you know?” (Lesson 2,

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Student Handout) When answering how they know, students will likely need to use the data they gathered as evidence. Similarly, some of the discussion questions (Lesson 2, Slide D) will likely need to be answered using the collected, e.g., “Which materials (if any) produced both attraction and repulsion with the magnet?”

- In Lesson 3, pages 88–90 (TE), students collect data (i.e., chart on page 89 and observations on page 90) to answer the question of whether air is involved in causing energy transfer through magnetic forces.
- Students discuss and determine methods for collecting data during Lesson 7 (page 164, TE).

Analyzing and Interpreting Data

Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.

- Students graph data from an investigation of the relationship of distance and magnetic force in Lesson 10 (TE, page 227). “Students will primarily be looking for numerical relationships in their data and find that the relationship between distance and magnetic force a nonlinear relationship with a negative association. Students who are taking advanced math classes may also notice that the relationship is an inverse square relationship. Highlight this idea, but remember that graphing and developing algebraic equations to describe scientific relationships are a high school target for NGSS.”
- In Lesson 11, pages 244–245 (TE) students construct graphs using a teacher prompt. “Say, Work with your group to find a pattern that will help you understand how the factor you investigated affects the strength of magnetic forces. Look back at your hypothesis and decide: Which variables should we graph to help us support or refute our explanation? Give student groups time to prepare graphs by drawing the x and y axes, determining appropriate scales, and labeling the variables along the axes. If students are struggling to prepare graphs, have them look back at graphs from Lesson 10 and describe how scales were determined.

Analyze and interpret data to provide evidence for phenomena.

- Students use a PHet simulation to collect data and analyze the size of the gap between the coil and the magnet (Lesson 5, Slide D).
- Students identify and interpret data using the I^2 strategy as they analyze the graph (Lesson 10, Slide 10).

Constructing Explanations and Designing Solutions

Construct an explanation using models or representations.

- After completing an investigation, students develop an explanation to explain how changing the distance between the cart and the magnets affects the energy transferred from the magnetic field (Lesson 7, page 166, TE).

Engaging in Argument from Evidence

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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.

- Students use prior experiences with writing arguments to write an argument around the questions of “Why did the music and magnets behave this way in the vacuum?” after viewing a video (Lesson 3, page 91, TE).
- Students make a written claim about energy transfer between objects in two magnetic fields. They support claims with logically organized evidence from their investigation (TE, page 167, TE).

Obtaining, Evaluating, and Communicating Information

Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).

- Students read *Music to My Ears* to gather more information to answer their questions. They use active reading strategies by reading in pairs, pause and discuss their ideas about the question, and then continue reading. “As they read, they should check off statements on their list of things they have figured out when they appear in the reading...they should put a star by new things they learn in the reading that will help them answer their questions in the second column of their chart” (TE, page 192).
- Students read BIG Electromagnets using close reading strategy. Before the reading they identify questions they are trying to answer, then they read individually and in groups to identify key ideas, and after the reading they summarize the key ideas in their notebooks (Lesson 9, Slide N).

Disciplinary Core Ideas (DCIs): Adequate

The reviewers found adequate evidence that students have the opportunity to use or develop the DCIs in this unit. The two DCI elements of PS2.B are developed in depth and students have opportunities to use this DCI. The science ideas in PS3.A and PS3.C that have been developed in prior OpenSciEd units are revisited and used appropriately. The new elements added in this revision add more content to the unit.

The following examples are evidence of this criterion:

PS2.B: Types of Interactions

Electric and magnetic (electromagnetic) 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.

- In Lesson 2, students discuss what they already know about magnets (page 67, TE), investigate magnet interactions, (page 68, TE), and then discuss the results to determine that magnets have both attractive and repulsive forces.

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- Students begin to explore whether the force acts differently at a distance closer to or further away from the magnet (TE, page 104).
- In Lesson 6, page 148 (TE), students discuss that the consensus model needs to include the idea that “flipping either magnet so that the poles are alike or the poles are opposite will change the shape of the magnetic field (from attractive when the poles are opposite to repulsive when the poles are alike).”
- In Lesson 7, pages 163–165 (TE), students explore the idea that size of repulsion is based on the distance between objects by varying the distance between a stationary brick with a magnet on it and a cart on a track with a magnet on it (with the magnets oriented to repel each other) and measuring how far the cart traveled (i.e., the size of the repulsive force) based on the starting distance between the objects (i.e., the magnets on the cart and the brick).
- Students investigate how changing the amount of energy transferred by an electric current affects a lightbulb. Students find evidence that the patterns in how electric current changes in a circuit correspond to patterns in the forces produced, including a relationship between the strength of the current and the strength of the force produced by the electromagnet. Students find out that computer changes the strength or amount of the electric current it provides, the direction of the current, and how rapidly it changes the current (TE, page 175).
- In Lesson 8, pages 180–181 (TE), students figure out that the amount of energy transferred by a current can be changed when the volume is increased (when the computer is the source of the electric current) and when they change the number of batteries in the system. The connection between the current and the size of the forces is expected to be addressed in the discussion on page 195 (TE) as well as in the reading title Music to My Ears on page 68 (SE).
- Students investigate the relationship between distance and force in Lesson 10 (page 227–228, TE). Students analyze the results of that investigation and participate in a Building Understanding Discussion (page 230, TE).

Forces that act at a distance (electric, magnetic, ~~and gravitational~~) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).

- In Lesson 4, page 104 (TE), the class begins to develop a working definition of magnetic fields based on the observations they have made so far including the behavior of iron filings around a bar magnet (page 101, TE) and then revises it after observing the behavior of iron filings around the coil connected to a battery (page 117, TE).
- Students use small compasses to map the magnetic field around a magnet and determine the direction of the magnetic force (Lesson 4, page 109, TE).
- In Lesson 5, page 135 (TE), students use an interactive computer model to engage in a structured exploration of the magnetic field between a permanent magnet and coil connected to a battery at different distances.
- Students explore the strength of force with different sizes of the gap between the coil and the magnet with attractive force vs. repulsive force (Lesson 5, Slide B).

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- In Lesson 9, page 211 (TE), students are asked to make connections between their consensus models and the following sentence (meant to summarize some ideas they had figured out): “Forces transfer energy into the magnetic field, and forces transfer energy out of the magnetic field.”

PS3.A: Definitions of Energy

A system of objects may also contain stored (potential) energy, depending on their relative positions.

- The handout for Lesson 7, Making Sense of Your Investigation Results, contains the following prompt: “Potential energy is what we call the energy that is stored in a system. In the Broken Things unit, we learned that anything that is springy can store potential energy that can then be released as kinetic energy to cause motion. You used a spring scale launcher to transfer energy into a cart to get it to move. In the spring system, the potential energy was stored in the spring before it was transferred into the cart. Where is the potential energy stored in the magnets system before it was transferred to the cart?” Students are asked to use prior knowledge of potential energy and transfer that knowledge to the magnet system.
- Students determine how much energy is stored in the magnetic field and find out “the amount of energy that is transferred into and stored in the field is dependent on the arrangement of the magnets in the field” (Lesson 9, Slide J).
- In Lesson 9, page 211 (TE), students are asked to make connections between their consensus models and the following sentence (meant to summarize some ideas they had figured out): “The amount of energy that is transferred into and stored in the field is dependent on the arrangement of the magnets in the field.”
- The introduction to Lesson 7 says “Changing the distance between two magnets changes the amount of potential energy stored in the field and the amount of energy that can be transferred out of it (as kinetic energy)” (page 159, TE). **The term potential energy is not consistently used throughout the unit. To aid in student understanding of how potential energy exists in a magnetic field, consider using the term when referring to the idea.**

PS3.C: Relationship Between Energy and Forces

When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.

- Students connect coils to a battery and learn that energy must be transferred to get the parts of the system to move (Lesson 2, page 70, TE).
- In Lesson 3, on page 85 (TE), it says, “Remind students that we know that because forces are causing movement in our speaker system, energy must be transferred into the parts that are moving.” Then the question is posed “How does energy transfer between things that are not touching?” Students begin to investigate (pages 88–91, TE) whether air is needed for the energy transfer.
- In Lesson 3, pages 89–90 (TE), students think about energy transfer in sound and how it is the same or different from energy transfer in magnet.

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- Students figure out “forces transfer energy into the magnetic field, and forces transfer energy out of the magnetic field” and find examples of how electromagnets are being used to make things move (Lesson 9, Slide J).

Crosscutting Concepts (CCCs): Extensive

The reviewers found extensive evidence that students have the opportunity to use or develop grade-level CCC elements in this unit. Cause and effect is developed in-depth including using the CCC to frame the unit, to help students to come to understandings of science ideas, and to frame questions used for investigations. Other crosscutting concepts are also used throughout the unit.

The following examples are evidence of this criterion:

Patterns

Graphs, charts, and images can be used to identify patterns in data.

- Data in a chart and in the corresponding graph is used to identify patterns in Lesson 10 (page 229, TE). Students use a strategy “Identify and Interpret” to assist in analyzing their graphs.

Patterns in rates of change and other numerical relationships can provide information about natural systems.

- Students identify patterns of rates of change in the frequency of vibrations from a sound source (Lesson 8, pages 182–183, TE).

Patterns can be used to identify cause-and-effect relationships.

- During a discussion of the location of iron filings around a magnet, students are prompted to observe how patterns are different and then to think about what causes the iron filings to move into a pattern. In the section that includes “Suggested Prompts,” “Sample student Responses,” and “Follow-up questions,” the pattern of the iron filings is connected to ideas about what is causing the iron filings to move and why they move to different parts of the magnet. (Lesson 4, pages 102-103, TE)
- Later in Lesson 4 (pages 114–115, TE), students identify the patterns of the magnetic field around an electromagnet using compasses. The students discuss what causes the compass needle to move in a certain direction and relate this pattern to the pattern noticed in the activity with iron filings. “Noticing that the iron filings are organized and that the compass needles align to trace the same invisible lines revealed by the filings is the first step for students in constructing and understanding fields and why they are useful for explaining phenomena” (TE, page 114)

Cause and Effect

Cause and effect relationships may be used to predict phenomena in natural or designed systems.

- Information for teachers on *developing* students’ understanding and use of cause and effect over the unit is provided in the three-page reading on “Using Cause-Effect Scaffolds to Support Science and Engineering Practices” (pages 59–61, TE).

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- Specific ideas about using cause and effect to make predictions is given on page 59 (TE).
“Using the Cause-Effect Scaffold to Support Making Observations and Predictions
Students use the cause-effect sentence frames to articulate their observations throughout the unit: When we change to the system (cause), we observed (effect) on system.
Students also use the sentence frames to make predictions using the following framing:
When we change (cause), we will observe effect.
Occasionally, students will be asked to explain their observations or justify their prediction by adding a “because” clause to the end of these frames.”
- In Lesson 1, students use cause-and-effect relationships to describe what happens to a system when they change it. Real-life examples (e.g., cell phone dropping) and sentence frames (e.g., “When we [change to the system], we observe [effect on the system]”) are provided to scaffold the thinking. This sets the foundation for later in the unit where students determine independent and dependent variables and writing investigable questions to understand the relationship between these variables (page 52, TE).
- In Lesson 1, page 53 (TE), students are asked to develop cause-and-effect-based questions, with the support of sentence and question stems. Some of the stems support students in thinking of mechanisms and predicting what will happen if something is changed. These questions are used in developing the DQB.
- In Lesson 2, page 74 (TE), students use stems to support them in making cause-and-effect-based predictions about what will happen with the magnet and coil of wire when the coil is connected to a battery.
- At the end of Lesson 2 (page 79, TE) students complete an Exit Ticket. Teachers are advised, “If necessary, spend some time at the beginning of the next lesson reinforcing the cause-effect structure before moving on to hypothesis building. Remind students that we can use the ‘when we _____ we observe _____’ sentence structure to talk about our observations when we change something, or we can add the word will (“we will observe ...”) to make predictions about what we think will happen when we change something.”
- In Lesson 7 (page 164, TE), students develop a hypothesis that will predict a cause and effect relationship. “Orient students to creating a hypothesis. Remind students that it is often useful to create a hypothesis before planning the details of an investigation. This means you will need to develop:
 - 1. a proposed mechanism that you want to test (theory, explanation, or model)
 - 2. a cause and effect relationship that you would be able to observe if the proposed mechanism were supported.”
- The students use the handout “Hypotheses and Variables” to predict their ideas about how changing a variable will lead to a different effect. “Use the handout to write a prediction about what will happen when you move the cart with the magnet closer to the other magnet, and then release it” (Lesson 7, Slide D)
- In lesson 10 (page 224, TE), students use their understanding of the distances that affect magnetic forces to make a prediction about what will happen in their investigation with magnets and scales.

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Phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.

- In lesson 9 (pages 207-212, TE), students build on their models from lesson 6 to include the new cause and effect relationships they figured out in the interim lesson. Students use the Cause-Effect Tracker poster to make sure they consider which cause-and-effect relationships should be included in their model. The suggested prompt - “What additional versions of the system do we need to include in order to capture each cause-effect relationship?” (page 210, TE) - may increase the likelihood that students recognize that the speaker producing sound is caused by multiple factors. After students individually add to the Cause-Effect Table, the teacher leads the following discussion:

“Once the table is complete, display slide D. Ask students to turn and talk about the question on the slide: Which of these cause and effect relationships do we need to explain how the speaker makes sound? Remind students that this can be any of the cause and effect relationships on the poster, not just the ones we came up with today. Say, in lesson 6, we used these relationships to explain interactions we observed between the permanent magnet and the electromagnet, isolated from the speaker system. Now it is time to come back to the speaker system to apply our ideas.” (TE, page 208) During this activity, students are using more than one cause and effect relationship to make sense of a phenomenon.
- In Lesson 12, page 255 (TE), students discuss the idea that a phenomenon may have more than one cause. “Consider that phenomena can have more than one cause. Say, we also figured out how to make magnetic forces stronger. What causes changes in the strength of magnetic forces? Look for student to say that there are a lot of things. Then say, it sounds like there are a lot of things that we can point to as a cause. It would be difficult to describe this using a nice chain like the one we worked on for home learning. I think we can say that some phenomena have many causes! Can we think of another example of another phenomenon that has multiple causes? Elicit a couple student ideas, then say, Cause-effect relationships can be complex. Sometimes phenomena can have more than one cause. And it can be difficult to figure out if one thing causes another thing without setting up an experiment. But as we saw in this unit, cause-and-effect relationships in systems can be a very powerful way for scientists to figure out phenomena.”
- Students construct a Cause-Effect Table in Lesson 6 (pages 143–145, TE). They add to the table in Lesson 9, 10, and 11. Group statements about cause and effect are put together into a public Cause-Effect Tracker. In making the Tracker, there is a **potential** for students to recognize that there can be multiple causes for a phenomenon.

Cause and effect relationships are routinely identified, tested, and used to explain change. (This is an element from the 3–5 grade band. On page 15 (TE) the developer states “having students familiar with using focal CCCs for this unit at the 3-5 grade-band level would be helpful”. This element is included in the list.)

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- Students observe a dissected speaker and discuss “How could we investigate what is causing the speaker to vibrate?” In their notebook, they also develop an initial model to explain what causes the homemade speaker to vibrate and make sound (Lesson 1, page 3, Student Edition).
- In Lesson 2, page 52 (TE), students establish a shared understanding of cause and effect and record examples of statements that have a cause (a change to the speaker system) and the effect that is observed.
- Students recognize a cause-and-effect relationship by seeing how the magnetic field causes certain orientation of the iron filings (effect) (Lesson 4, page 104, TE).
- Students construct a Cause-Effect Table in Lesson 6 (pages 143–145, TE). The table records the cause (the change to the system), the effects on the system observed and a reason for this occurrence.
- In Lesson 6, page 145 (TE), the class creates a list identifying all the changes they have made to the speaker system through the unit as well as the effects of those changes and mechanisms underlying the effect. They are then asked to use this list to, “Refine a model of the [speaker] system that captures what we have figured out about cause-and-effect relationships” (Lesson 6, Slide E). On page 148 (TE), it states that the students’ consensus model needs to explain change by including the idea that “flipping either magnet so that the poles are alike or the poles are opposite will change the shape of the magnetic field (from attractive when the poles are opposite to repulsive when the poles are alike).”
- In Lesson 11, students develop a cause and effect flow chart for home learning that shows the sequence of events from turning on the music player to the music we hear (Lesson 11, Slide Q).

Systems and Systems Models

Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.

- In Lesson 1, students identify each part of a speaker system and explain why it is important (page 43, TE). Students then develop a model of the homemade speaker and show how parts work together in the system (page 3, Student Edition).
- Students use systems and system thinking to generate and organize their questions on the DQB. Students post their question next to the specific part of the system (see poster with post-it notes on page 55). Students reflect on any parts of the speaker system that have few or no questions posted on the DQB and generate more questions so each important part of the system is investigated (Lesson 1, pages 54–55, TE).
- In Lesson 6, page 148 (TE), a class discussion of their models includes these questions:
 - What parts do we need to include?
 - How can we represent the forces between the magnet and the coil of wire when the forces are repulsive versus when they are attractive?
 - How should we represent the magnetic field?
 - How should we represent both cause and effect for each of these relationships?

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- In lesson 9 (pages 207-212, TE), students build on their models from lesson 6 to include the new thing they have figured out in the interim lessons. Previous models only had the speaker, but students were led to recognize that there was no source of energy to the coil to make it a magnet. Their updated models in lesson 9 include the input of electricity from the media player and the flow of energy in the system.

Energy and Matter

Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).

- Lesson 7, *Making Sense of Your Investigation Results* handout, says “In the Broken Things unit, we learned that anything that is springy can store potential energy that can then be released as kinetic energy to cause motion. You used a spring scale launcher to transfer energy into a cart to get it to move. In the spring system, the potential energy was stored in the spring before it was transferred into the cart. Where is the potential energy stored in the magnets system before it was transferred to the cart?” This question asks students to identify different forms of energy. Page 166 (TE) advises teachers to look through students’ completed handout for demonstration of the idea that “energy transfers from the magnetic field into the magnets to make them move” which is a transformation from energy in field to kinetic energy.

Suggestions for Improvement

SEPs

- A chart “Developing and Using Science and Engineering Practices (by Lesson)” is included in the unit materials. The outline of lessons on pages 22–31 also presents this information in a lesson-by-lesson format. Consider organizing a chart by SEP elements instead of by lessons for teachers who are interested in tracking student progress in these elements and developing grading systems that reflect specific elements of the SEP.

DCIs

- Students have learned the term potential energy in a previous unit, but the term is not used consistently through the unit. The developer instead uses wording such as “energy being transferred out of the field”. Consider continuing to use the term potential energy in lessons that refer to idea.

CCCs

- Some of the activities used for the CCC of Cause and Effect are at the 3-5 grade band level. Throughout the unit, remind teachers of why Cause and Effect is being used at a lower level, such as filling gaps in student experiences, providing scaffolds for students, serving as a base for using the CCC at the 6-8 level, or because the focus on using Cause and Effect to explain change is the most useful element for a particular task even though it is at the 3-5 level.
- Consider restructuring the public Cause-Effect Tracker to show that a phenomenon may have more than one cause. Instead of using the Tracker as a running record of identified cause and effect statements, the Tracker could be organized such that it names a single aspect of the

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phenomenon at the top and lists multiple causes for that phenomenon. Consider starting a new tracker for additional parts of the phenomenon.

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

The reviewers found extensive evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena. There are numerous events where students are expected to figure what causes a speaker to vibrate 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 phenomenon.

The following examples are strong evidence of this criterion:

- In Lesson 1, the CCC of Cause and effect is used to organize student thinking about the DCIs and to scaffold the development of practices. For example, in this lesson, students use cause and effect to develop models about interactions between the parts of the system in order to scaffold the practice of asking questions. There is also a Teacher reference guide that explains how to use cause and effect scaffolds to support science and engineering practices to help students make observations and predictions, ask questions, and frame hypotheses (TE, page 59–61).
- There are three-dimensional lesson-level performance expectations in every lesson that describe the integration of the three-dimensions. For example:
 - Lesson 4, page 93 (TE): “Ask questions about the cause and effect relationships that produce patterns we observe in the direction or size of forces in a magnetic field around a permanent magnet as it interacts with another object near it.” In this lesson, students analyze observational data showing real patterns that help them identify what causes magnetic fields between two magnets
 - Lesson 5, page 129 (TE): “Use a computer interactive to model the effect on patterns in a magnetic field when we add an electromagnet to the single magnet system.” During this lesson, students use patterns to figure out the magnetic fields surrounding a magnet and a coil of wire, by manipulating the orientation of both the magnet and the wire as well as the distance between the two. Here they are using patterns to identify what causes the change.
 - Lesson 6: “Develop an initial model to describe how forces and energy transfer in magnetic fields explain the cause and effect relationship between parts of a speaker system (magnet and a coil of wire).” The class develops a model that includes the magnetic field around a coil of wire and how the magnetic field between the coil of wire and magnet changes with attractive forces and repulsive forces. The cause-and-effect

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relationship is used to explain the process that occurs within a system, and students represent this interaction through modeling.

- o Lesson 10: “Plan an investigation to produce data to support hypotheses about the cause-and-effect relationship between distance and magnetic forces, including identifying independent and dependent variables.” The class co-designs an investigation, connecting the cause with the independent variable and the effect with the dependent variable. In writing their hypothesis, students are reminded about the connection between cause-effect and predictions. “Remind students of the sentence frame we have been using to write hypotheses: If explanation/theory, then when we cause we will observe effect.”

Suggestions for Improvement

N/A

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**

The reviewers found extensive evidence that lessons fit together coherently to target a set of performance expectations. Throughout the unit, connections are made to prior discussions (including in previous units) and student questions. Questions drive each lesson to build an understanding of core ideas and concepts. Students revisit their original questions while also having the opportunity to develop new questions and new ideas for investigation. Guidance is provided to support the cultivation of new questions arising from related phenomena or prior experiences. Students revisit the unit phenomenon multiple times, taking stock of how well they can explain the phenomenon and creating key linkages across the unit. Guidance and instruction on how to recognize what students figure out in a lesson but also what questions are left unanswered or what new questions students have are used to motivate the next investigation. **However, printing the lesson-level question in the Student Edition detracts from student agency over this process and may lead to the perception that questions are pre-determined by the teacher.**

The following examples are strong evidence of this criterion:

- In Lesson 1 page 53 (TE), guidance is provided to support the cultivation of new questions arising from related phenomena or prior experiences. The teacher explains to students how to create the DBQ. Students form a scientist circle and each student shares their question and puts their question on the DQB near the section of the model it is most related to. The student also says

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what other question on the board it relates to and why or how. Students sort questions into categories or themes they see in the clusters of questions. Based on the questions on the DQB, students develop initial ideas for future investigations on the “Ideas of Investigations”.

- Students create new questions after viewing a demonstration of the arrangement of iron filings around a magnet in Lesson 4 (pages 102–103, TE). Students refine their questions by determining which questions are testable in the classroom. Teachers are given the following guidance: “Encourage them to consider questions that we can test in the classroom and those that require us to gather more evidence to make our model more complete or accurate. Discuss their observations by using the prompts above.”
- The teacher points out gaps in the current understanding. For example, “from this lesson we know what a magnetic field looks like around one magnet, but this system doesn’t look like our speaker system...Our speakers have a permanent magnet and an electromagnetic, both of which have magnetic fields. So we aren’t getting the full picture.” This creates a need to discover more and motivate their learning (page 120, TE).
- During Lesson 5, students revisit the DQB by finding questions related to the distance between the magnet and the coil. This reminds the students why they might include two versions of the diagram for each type of force (close together and farther apart) (page 134, TE).
- Students use the cause-effect table to organize their prediction and explanation. Using the same format though the unit allows students to identify cause-and-effect relationship of magnetic forces (Lesson 7, Slide D).
- Guidance is provided to teachers on how to move student thinking by determining what questions still remain and how they might investigate to find out (Lesson 3, pages 191–192, TE). “Students are asking questions of their own that arise from their careful observations of the behavior of a speaker and a lightbulb when connected to a battery and a computer. Some of what they observe may be unexpected, and they form these questions to seek additional information. Encourage students to ask questions that we can investigate in class or that we can use the resources we have available in our lab to find additional information to answer our questions. The additional information to answer our questions this time will come from the scientific reading in the next activity.
- Students revisit and add more questions to the DQB in Lessons 1, 4, 6, and 9.
- In Lesson 12, page 257 (TE), students return to the DQB and use sticky dots to identify “questions we agree we can answer, questions that we have at least a partial answer to, and questions we cannot answer at all.”

Suggestions for Improvement

- Some ways that students could have more control over the choice of the next lesson-level question include:
 - Instead of printing the question at the top of each lesson, consider leaving an empty rectangle, a line, or a space, and have the class come up with the wording of the question.

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- Consider advising teachers to provide students with only one lesson at a time so that students will not “look ahead” to future questions.

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

The reviewers found adequate evidence that links are made across the science domains. The phenomena of speaker vibration can be fully explained using content with the physical science domain. The unit focuses on one domain and the phenomena driving the lesson can be fully addressed within that domain or the related science domains relevant to the explanation are identified as prerequisite learning.

Suggestions for Improvement

To receive an Extensive rating, units would need to focus on core ideas from two or more disciplines and use CCC elements to intentionally and explicitly make connections across the science disciplines addressed in the lessons.

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

The reviewers found adequate evidence that the materials provide grade-appropriate connections to mathematics, English language arts (ELA), history, social studies, or technical standards. Throughout the unit, students use grade level mathematics and reading skills to explain and understand the phenomenon of how a speaker vibrates. The provided texts help students to develop understanding and explanations of the scientific concepts and phenomena. There are also multiple opportunities for high level verbal discourse in a variety of formats and scenarios (partners, small group, and whole class discussions). Students use grade level writing skills to explain and communicate their understanding of science concepts. Grade-appropriate mathematics and ELA are purposefully incorporated into lessons with teacher support to help students make these connections. Correlation to CCSS appears in boxes at the end of some units (pages 167, 235 TE).

The following examples are evidence of this criterion:

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ELA-Literacy

CCSS.ELA-LITERACY.SL.6.1.c *Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.*

- When the class is building the DQB, students explain why or how their questions are linked to someone else's question. This emphasizes the importance of listening to and building off each other's ideas and to help scaffold student thinking. There is explicit scaffold and support to help the students engage in this type of conversation. "If students can't figure out which question to connect theirs to, encourage them to ask the class for help. After an idea is shared, ask the original presenter if there is agreement and why, and then post the question" (page 57, TE).

CCSS.ELA-LITERACY.W.8.1. *Write arguments to support claims with clear reasons and relevant evidence.*

- Students make a written claim about energy transfer between objects in two magnetic fields. They support claims with logically organized evidence from their investigation (TE, page 167).

CCSS.ELA-LITERACY.SL.8.1.A: *Engage effectively in a range of collaborative discussions (one-on-one), in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.*

- Informal discourse occurs when students are asked to "Turn and Talk." Pairs of students respond to a prompt, frequently before a whole class discussion occurs.
- Whole class discussions are used at strategic points in the unit. In Lesson 1 (page 39, TE), the whole class engages in a discussion of their initial ideas. The teacher is provided with this information: "The purpose of this brief discussion is to (1) give students a chance to reflect on what they already know about forces and sound from previous units and (2) motivate the dissection of the speaker by revealing a gap in what we know (the cause of the force in the speaker). To draw out student ideas, ask, what causes the force in a drum (or a recorder)? (hitting it with a hand or a stick, air moving through the instrument). This will engage students in retrieving ideas from the previous unit and remind the class that forces are typically caused by contact (between the hand and the drum or the air and the recorder)."
- After an investigation, students engage in a building understanding discussion (Lesson 8, page 195, TE). The purpose of this type of discussion is "to focus students on drawing conclusions based on evidence. Your role during the discussion is to invite students to share conclusions and claims and to push them to support their conclusions and claims with evidence."
- Students engage in consensus discussions when they are expected to process new information and have the class come to a common understanding (Lesson 1, page 49).
- Scientist Circles (with a learned protocol) are used to share findings of investigations (Lesson 11, page 246).

CCSS.ELA-LITERACY.RI.8.1: *Cite textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text.*

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- Close reading strategies are included with each reading selection. (Student Handbook, page 65, 67)
- Associated with each reading selection is a method for processing the information from the reading. (Student Handbook, page 19).
- A jigsaw method is used to process the information in three readings in Lesson 9 (page 214).

Mathematics

Connections to mathematics are grade level appropriate. Mathematics is used to analyze and organize investigation results. “The goal of integrating mathematics within units is to use mathematical understanding and practices to develop and reinforce important science ideas and practices, while supporting students in strengthening their math understanding and practices, and demonstrating the importance of mathematical thinking and practices to science. The OpenSciEd units are intentional in their placement and purpose of mathematics. Mathematics is intended to help the storyline along, to help to clarify some piece of the puzzle students are figuring out, or to give students tools to highlight, analyze, and interpret important patterns in the data they are exploring” (Teacher Handbook, page 46).

When applying mathematics, materials connect to and reinforce the Common Core State Standards for Mathematics. Mathematical analysis is not meant to be used in isolation of developing understanding of the target science ideas. Connections to mathematics are noted at the end of each lesson where appropriate.

- The section “What are prerequisite math concepts necessary for the unit” provides helpful information what mathematics concepts and skills should have from mathematics class such as “CCSS. Math. Content. 7. PR. 1” and “CCSS. Math. Content. 6. NS. C. 8” (TE, page 17).
- **CCSS.MATH.8.F.B.4** *Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.* Students determine the rate of change of the cart from the data they collected. They interpret this rate as the speed of a cart moving along a track (TE, page 167).
- **CCSS.MATH.8.F.B.5:** *Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.* In this lesson, students gather data describing the effect of changing the distance between two magnets on the strength of the magnetic force pairs between them. They use these data to describe and graph functions that represent the relationships between distance and force for attractive and repulsive forces (Lesson 7, page 167, TE).
- **CCSS.MATH.CONTENT.8.SP.A.1** : *Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.*

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In this lesson, students record data from their investigation in a table and use these data to create a graph that allows them to look for patterns of association between the distance between two magnets and the strength of magnetic forces.

Suggestions for Improvement

- A random sampling of text run through a text analyzer (Lexile) shows that the reading level of the selections range from grade 4 through grade 8. If there is a reason that some of the readings are below grade level, consider stating that reason in the materials for teachers. Alternately, consider changing the readings to bring them up to a middle school reading level.
- Consider using reading materials that include news articles, journal articles, infographics, or websites of scientific entities.

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

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)

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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 Authority: **Extensive**

The reviewers found extensive evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world. Student questions and prior experiences related to the phenomenon are used to drive the lesson and sense-making. Students are provided with an opportunity to experience the phenomenon firsthand and are provided with an opportunity to discuss their prior experiences. Throughout the unit, students are provided with opportunities to use their prior knowledge to explain how a speaker works and provide ideas for how it can be investigated.

The following examples are strong evidence of this criterion:

- The materials provide support to teachers to engage students in a phenomenon that is experienced directly, and this hands-on experience serves as an on-ramp to understanding. Trying to understand how a common object works—in this case a speaker—creates an authentic scenario for the unit. In addition to having an authentic phenomenon, students will have just finished a unit about the sound that comes from a speaker, making how the speaker works particularly relevant to students. The students start by dissecting a speaker to address the question of “What force(s) causes a speaker to vibrate?” Teacher materials highlight the relevance of music and music technology in the lives of young people as a relevant context for the lesson for many students. It is also suggested that “students will find the anchoring phenomenon more compelling if it is presented in a meaningful context. Ask students where they see speakers every day. Students may suggest the speakers in their phones, their headphones, the school loudspeaker, a Bluetooth speaker, or a sound system at home” (page 39, TE).
- Students are able to experience the phenomenon firsthand, as indicated below:

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- Lesson 1: Students observe a dissected speaker (through teacher demo or video) and have opportunities to build their own speaker (TE, pages 40–41).
- Lesson 4: Students observe how iron filings help determine where the magnetic field is located around the magnet through teacher demonstration. They also investigate the field using compass needle themselves (TE, page 101).
- Many home learning opportunities are provided to help students connect their experience with their family and their community. Students are provided with opportunities to connect their previous knowledge and personal experiences with magnets to make learning relevant to them. For example:
 - Lesson 2: Students are encouraged to bring in a magnet from home for classroom investigations. Students can share where they found the magnet. The teacher uses this opportunity to point out how common magnets are in our lives across a variety of contexts (page 67, TE). Students can also bring in coins from other countries to see whether they are magnetic or not (page 71, TE).
 - Lesson 2: Students are encouraged to research and share the word for magnet in another language. This honors family and community knowledge into the classroom and also provides opportunities for multilingual students to make content connections in their language (page 73, TE).
 - Lesson 4: Students take a small compass home to put near a variety of objects or devices in their homes to find evidence of a magnetic field. They take pictures of their observations and share with the class. It is also suggested that students can share the photos anonymously for the teacher to put into a slideshow. This addresses equity to students who may not have a camera (page 113, TE).
 - Lesson 9: Students ask family and community members if they know of something that uses electromagnets to make things move and conduct more research using the internet or books and articles from the library (page 209, TE).
- Students experience the phenomenon as directly as possible as the materials provides options for firsthand experiences or videos if it is not possible to provide firsthand experiences. For example, on Lesson 1, page 40 (TE), options are provided for: dissecting the speaker in real time, using a previously dissected speaker, or playing a video.
- In Lesson 9, page 231 (TE), students are able to connect their explanation of how the speaker works to other objects in their lives. The teacher is encouraged to say, “We have answered so many of our questions about the speaker! It really feels like we understand how this system works. What about some of the other things we think use permanent magnets and electromagnets? Can we explain those systems too? Let’s spend some time sharing our research with others, and looking for common ideas.” Comparisons to the speaker are made such as small uses of magnetism like the speaker or very large uses compared to the speaker.

Suggestions for Improvement

N/A

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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

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. Student ideas drive most of the instruction in the unit. Students share their ideas to build upon prior understanding. The teacher acts as an expert facilitator, drawing out student ideas while coordinating movement toward targeted learning. Throughout the unit, students use others' ideas that are shared in class through discourse and model revisions to improve or change their own thinking. Students demonstrate new thinking based on peer and teacher feedback as well as personal reflection.

The following examples are strong evidence of this criterion:

- Students have multiple opportunities to share their thinking.
 - The structured opportunities for sharing ideas are indicated in the student materials with icons for *turn and talk*, *with your group*, and *with your class*. Some lessons also include *scientists circle* with goal discussions such as *building understanding discussion*. Additionally, example norms and guidelines are provided to teachers and students to provide structure and support to these interactions so that all students can have opportunities to share their ideas. For instance, on page 31 of the teacher handbook, there are example norms and talk moves to support those norms and on page 33, strategies are given for facilitating a *building understandings discussion*.
 - By using the Progress Tracker throughout the unit, students think about their learning and express their ideas, sometimes in both words and pictures.
- The materials describe the purpose of peer assessment on page 21 (TE): “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. This document is designed to give you options for how to support this in your classroom. It also includes student-facing materials to support giving and receiving feedback along with self-assessment rubrics where students can reflect on their experience with the process. Peer feedback is most useful when there are complex and diverse ideas visible in student work and not all work is the same. Student models or explanations are good times to use a peer feedback protocol. They do not need to be final pieces of student work, rather, peer feedback will be more valuable to students if they have time to revise after receiving the peer feedback. It should be a formative, not summative type of

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assessment. It is also necessary for students to have experience with past investigations, observations, and activities where they can use these experiences as evidence for their feedback.”

- Students have opportunities to give and receive peer feedback. For example:
 - Students participate in a Consensus Discussion in Lesson 6, page 147 (TE). “The students’ role is to offer proposals for ideas to include in the model and how to represent those ideas, to support or challenge proposed ideas from peers, and to come to consensus about what should be included in the model.”
 - In Lesson 11 page 242 (TE), student groups use the “Peer Feedback Rubric for Planning Investigations” to evaluate and offer advice to the investigation plan of another group.
- Students get feedback from the teacher. For example:
 - In Lesson 7, students develop a plan for an investigation and record this in their notebook. Teachers are guided to provide feedback in the form of noticing and wondering. Sample feedback is included and students can alter their plan before conducting the investigation. (TE, page 20).
 - Another example of teacher feedback occurs when students modify their models in their notebooks (page 29, TE). Teachers use the Rubric for Model in Lesson 9 to structure feedback to students. Students have the opportunity to reflect on teacher feedback before engaging in building a consensus model with the class.
- The use of norms in the classroom ensures that students have a safe environment for sharing these ideas:
 - Lesson 1: When students develop an initial consensus model, the teacher reminds the students that “we listen to one another, press on one another’s ideas, and ask questions of one another and that it’s OK to disagree with ideas but it’s important to be respectful...You can use slide J to remind students of the classroom norms” (TE, page 48). This routine ensures that students listen to their peers and use their peer feedback as part of their learning.
 - Lesson 1: Using the Scientist Circle routine helps facilitates consensus discussion. Call-out boxes are embedded in the teacher guide to remind about the important features such as “students sitting so they face one another to build a sense of shared mission and a community of learners working together; celebrating progress toward answering students’ questions and developing more complete explanations of phenomena” (TE, 49).
 - Lesson 2: The teacher uses strategic talk moves to help students identify important ideas. “When you hear an important idea, you can 1) revoice the idea, 2) ask others to restate the idea that the previous person shared, and 3) ask others to share what about their own ideas is similar to it. These talk moves allow students to spend more time with these ideas, providing space for other students to work with refining and solidifying these ideas” (TE, page 72).
 - Lesson 6: During the gallery walk, students identify one idea in other group’s model that would be helpful for the class and argue how their own model represents cause-and-effect relationship or part of the system better than other groups (TE, page 147).

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- Lesson 6: Strategies are provided on facilitating Consensus Discussion: "The teacher's role is to prompt students to share what needs to be in the model, evidence they have to support their ideas, and how to represent it. The students' role is to offer proposals for ideas to include in the model and how to represent those ideas, to support or challenge proposed ideas from peers, and to come to consensus about what should be included in the model." Prompts are also provided to guide the discussions (TE, page 147).
- Lessons 9 and 12: Students have opportunities to apply their understanding to additional phenomena such as electric motor and magnetic levitation trains. In Lesson 12 the transfer task allows students to choose an electromagnetic device to explain how it works.

Suggestions for Improvement

N/A

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**

The reviewers found adequate evidence that the materials identify and build on students' prior learning in all three dimensions. Materials make clear the expected level of proficiency students should have with all three dimensions for the core learning in the unit. The unit materials describe a logical progression of through the unit, but the learning sequence is not always related back to prior student experiences.

The following examples are strong evidence of this criterion:

- The section "What should my students know from earlier grades or units?" lists the DCI elements from grades 3 and 4 (3-PS2.A, 3-PS2.B, 4-PS3.A, 4-PS3.B, 4-PS3.C); SEPs at the 3–5 grade-band level including Asking Questions and Defining Problems, Developing and Using Models, Planning and Carrying Out Investigation, Engaging in Argument from Evidence; and CCCs at the 3–5 grade band level (Cause and Effect, Systems and System Models, Energy and Matter) (TE, page 14–15).
- The section "What are some common ideas that students might have" has a list of students' relevant ideas on energy, forces, and magnets. It is emphasized that these should be not be treated as misconceptions, instead they should be used as productive ideas to build students' understanding (TE, page 16). "It is valuable to think of ideas like these not as misconceptions that need to be erased but as productive ideas that we can use to build understanding. Not only does this help some students feel more comfortable talking about science and build a scientific identity, it improves science learning across the board. For example, in Lesson 3 we are expecting that

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some students will suggest that energy transfers through air in the speaker system (see relevant idea 23 above). Regardless of if the idea is wrong or right, this is a well-informed idea based on our ideas about energy transfer from the Sound unit and from experience (we see that the wind can make things move and transfer energy, for example). Students who put forward this theory are transferring content knowledge and exercising scientific reasoning in a productive way.”

- Each lesson has a section called “Where We Are Going and NOT Going”. Information about what students should already know is provided. Advice is given to reinforce these ideas if students do not remember topics from the previous grades. An example of this is on page 66 of the Teacher Edition. “In OpenSciEd Unit 8.1 Why do things sometimes get damaged when they hit each other? (Broken Things) they reviewed and built on the idea that each force acts on one particular object and has both a strength and a direction (3-PS2.A). What they may not remember from previous grades is that electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact and that the strength of the forces between two magnets depends on their orientation relative to each other (3-PS2.B). Be prepared to reinforce this idea.”
- Connections to the science ideas developed in previous OpenSciEd units are noted throughout the unit.
 - At the beginning of Lesson 1, page 39 (TE), students review what they remember about speakers. “Review the consensus model from OpenSciEd Unit 8.2 Sound. Focus on what students figured out about the speaker.”
 - Students draw on prior experiences with writing arguments in Lesson 4 (TE, page 93). “Students should draw on their previous experience with argumentation and explanations to complete this task. Argumentation is a focal practice in OpenSciEd Unit 8.2, *How can a sound make something move?*”
 - In Lesson 6, page 152 (TE), the teacher reminds students of prior learning. “Use the photo on the slide to remind students about the phenomenon of the windows and the sound from the truck from OpenSciEd Unit 8.2: Sound Waves.”
- The teacher’s guide provides prior learning expectations and additional guidance for the Disciplinary Core Ideas as outlined in the below examples.
 - In Lesson 1, the teacher reminds the students about balanced and unbalanced forces from the previous unit by asking them “we know that in order to change the motion of something, you have to apply unbalanced forces to it. What is pushing or pulling on the thing that is vibrating and making sound?” (TE, page 46) The teacher also summarizes students’ discussion about making sense of the speaker by saying “when a hand hits a drum, it puts a force on a drum and the drum puts a force on the hand. When a phone collides with the ground, the ground puts a force on a phone and the phone puts a force on the ground. Both of these are examples of contact forces” (TE, page 48).
 - The teacher helps students build scientific vocabulary by using both everyday and scientific terms in Lesson 2. When students mention that something sticks to a magnet, the teacher elaborates by saying that the object is being pulled toward or pushed away. Later in the lesson the students begin to use the word force, attraction, and repulsion. “It

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is important for students to spend time thinking about these forces using a hybrid of everyday and scientific language that will help them make conceptual connections between science and their experiences.” Building Understandings discussions are important routine to help students build on DCIs as they discover scientific principles (TE, page 67).

- Prior learning expectations and additional guidance for the SEP are outlined in the following example.
 - Teachers are provided an explanation of how SEPs will be developed in several of the right-side comments. “Asking questions is a focal practice in this unit. In middle school, the NGSS specifies that as part of the development of this practice, students are expected to “frame a hypothesis based on observations and scientific principles,” but only “when appropriate” (Appendix F, p. 5). These words are chosen carefully because asking questions, making predictions, and framing hypotheses are not the same thing. It is important to note the distinction between the types of predictions and questions students have been making up until now and the hypotheses they will write in this lesson. According to Appendix H of the NGSS, a hypothesis is an “idea that may contribute important new knowledge for the evaluation of a scientific theory” (p. 5). It is not simply the articulation of a pattern (“if this, then that”), but rather the articulation of a pattern that, if established, would lend support to a mechanistic model or explanation for a phenomenon.” (TE, page 85)
 - This comment to teachers does not connect back to the prior student learning expected and expressed on page 15 (TE).
- Prior learning expectations and additional guidance for the CCC are outlined in the following example.
 - Examples of this are included in the right-side comments. “This is an opportunity to help students recognize the cause-and-effect relationship between putting the iron filings in a magnetic field (cause) and the orientation of the iron filings (effect) and consider the mechanistic how or why explanations for this relationship. Use the language of cause and effect introduced in earlier lessons to point this out in order to make clear that these tools are crosscutting. For example, say, when we sprinkle iron filings around a magnet then we will observe the iron filings align in patterns. How or why are the magnetic filings lining up that way? Look for students to talk about force pairs at this point. Some students may mention the magnetic field a mechanism.” (TE, page 104) In this example students are observing patterns (an element from the 3-5 grade band) and using that pattern as a basis for developing a causal explanation (an element from the 6-8 grade band).
 - This comment to teachers does not connect to the list of student prior experience listed on page 15. (TE)

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In addition to listing prior experiences for the SEPs and CCCs on page 15 (TE), connect these in the appropriate places in the unit. Before explaining how the lesson progresses, remind teachers of the expected prior learning and provide suggestions for adaptation if students are above or below this level

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

The reviewers found extensive evidence that the materials use scientifically accurate and grade-appropriate scientific information because all science ideas included in the materials are accurate and there is strong support for teachers to clarify potential alternate conceptions that they (or their students) may have.

The following examples are strong evidence of this criterion:

- On page 16 (TE), there is a list of some ideas about energy, forces, and magnets that students of this age may have. The developers also express their thinking about dealing with these ideas. "It is valuable to think of ideas like these not as misconceptions that need to be erased but as productive ideas that we can use to build understanding. Not only does this help some students feel more comfortable talking about science and build a scientific identity, it improves science learning across the board. For example, in Lesson 3 we are expecting that some students will suggest that energy transfers through air in the speaker system (see relevant idea 23 above). Regardless of if the idea is wrong or right, this is a well-informed idea based on our ideas about energy transfer from the Sound unit and from experience (we see that the wind can make things move and transfer energy, for example). Students who put forward this theory are transferring content knowledge and exercising scientific reasoning in a productive way. Simply telling students that the energy does not transfer through the air in this case and explaining that energy transfers through a magnetic field is not as productive as investigating the inaccurate theory and building evidence against it that will help students construct a new, more accurate conceptual model for magnetism. So in this unit (Lesson 3), students spend time exploring the claim that energy is transferred between magnets through the air in order to build evidence for a more scientific conceptual model that includes invisible magnetic fields."
- Each lesson has a "Where we are going (and NOT going)" section which describes the background and how the lesson fits in the storyline.
- On page 25 (TE), the following guidance is provided: "If students are not accurately representing the magnetic field at this point, take note of what they are struggling with: Is it the direction? Is it that the magnetic field is only on the ends of the magnet, not all the way around? Then use the simulation on day 4 of this lesson to highlight for students these features of the magnetic field."

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- Additional guidance is provided to make sure the teacher is careful with the choice of words and not to introduce misconception. For example, in Lesson 4 the teacher is reminded to “be careful when you discuss direction and the magnetic field. The field itself does not have direction. The field tells us about forces on other magnets or magnetic objects in the field, and those forces have a direction. Being careful with the way you phrase questions and discussions will help students construct a scientifically accurate conceptual model for magnetic fields” (TE, page 107).
- Safety Precautions are provided when students are conducting investigations about handling electronic devices, light bulbs, batteries (Lessons 2, 4, 8, and 11).
- “Additional Tips and Notes for Success” is also provided in Lesson 4. It is helpful to have photos to show the actual set up and ways to troubleshoot any issues that may arise (TE, page 125–126).

Suggestions for Improvement

N/A

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: Extensive

The reviewers found extensive evidence that the materials provide guidance for teachers to support differentiated instruction. There are a variety of strategies with examples and guidance for the use of that support to help students in the sense-making process, especially for language learners. Extra support is provided throughout the lesson for students who are struggling to meet performance expectations with guidance on how to determine their understanding at that point in the lesson and how the suggested support will help students demonstrate progress towards understanding the PEs.

The following examples are strong evidence of this criterion:

- The Equity callouts give strategies for addressing the needs of specific populations.
 - In Lesson 1, suggestions are provided for students with special needs. “If students lightly touch the speaker, they can feel the vibrations. This could be particularly powerful for students who are visually or hearing impaired” (TE, page 40). The strategy of color coding

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the model is introduced, with an alternate strategy of letter or number coding for color blind students: “Although color coding is a useful way to quickly reference the parts of the model, letter and number coding helps ensure accessibility for any students who may be color-blind” (TE, page 49).

- Specific suggestions are provided for students who are language learners:
 - Lesson 1 provides teachers with this guidance: “Have students jot down some ideas in their notebooks after their partner talk and before sharing out. This can be particularly supportive for emergent multilingual students” (TE, 50).
 - In Lesson 2, the teacher helps students build scientific vocabulary by using both everyday and scientific terms. When talking about push and pull, teacher is suggested to use hand gestures to mime a push and pull. “This is particularly important for emergent multilingual students, but will benefit all students” (TE, page 67).
 - Vocabulary development for all students is emphasized through the unit. “It can be very helpful for all students, and particularly emergent multilinguals, to break down compound words like electromagnet. Ask students to reason about the first part of the word by asking, what does “electro” sound like? What other words have you heard that sound like that? Students will probably say “electricity.” Encourage students to consider and suggest cognate words in other languages as well, such as *electricidad* (Spanish), *électricité* (French), *elektrichestvo* (Russian transliteration), or *Elektrizität* (German). Then summarize the idea of putting both words together, “electricity” and “magnet”, to make a single compound word that indicates that this is a different kind of magnet than a permanent magnet in that it needs electricity in order to become a magnet (cause and effect)” (Lesson 3, page 85, TE).
 - The section called “Developing Scientific Language” in the Teacher Handbook (pages 51–52) provides detailed guidance on how to support scientific language development especially for language learners.
- Suggestions are provided for struggling learners:
 - Lesson 3: If students struggle to connect a claim to evidence, they can work in groups to develop a consensus explanation, share as gallery walk and leave feedback on sticky notes. The teacher can also pair students strategically by ability (TE, page 91).
 - Some support is provided for students who read below grade-level. For example:
 - Close reading scaffolds are included and can be used with any reading selection.
 - By working with a group in the jigsaw activity (page 214, TE), students who struggle with the reading material have other students to help process the material.
- Alternate activities allow teachers to make decisions based on their students’ interests and level of understanding.
 - Alternative activities for the speaker dissection are provided in Lesson 1, page 40 (TE). “There are three options for observations in this activity: (1) Dissect a speaker in real time,

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- (2) use a previously dissected speaker, or (3) use a video of a speaker dissection.”
- Another alternate activity is provided in Lesson 4, page 101 (TE): “This activity is a teacher demonstration, but if you have extra time and supplies, you may choose to do this as an investigation with small groups of students.”
 - In Lesson 8, page 176 (TE), an alternate activity is described: “If your materials are limited or you are struggling to get the three whole-class investigations to work using the equipment you have, you may use the three videos available. This is not ideal since doing the demonstrations will provide students first-hand evidence for these phenomena.
 - A Teacher Reference is provided to guide in describing enrichment activities and extensions for students who have a high level of interest or prior knowledge (page 199, TE). Suggestions for extensions include:
 - A suggestion in Lesson 4 is that students who are curious about different kinds of magnets can research other kinds of magnets (ferromagnets, paramagnets, permanent magnets, electromagnets, etc.) and put together a “magnetic zoo” poster to share with the class. An optional home reading activity is also provided.
 - In Lesson 9, students who are interested in learning more about electric current are offered an extension activity. There is guidance for teachers on how to offer additional learning with “Electricity extension opportunity” for Lesson 8–12. For example, in Lesson 8 there is a handout “What is electric current?” that offers home learning for students to explore more about electrons and complete a PhET computer interactive (TE, page 199).
 - The Teacher Reference on page 199 (TE) provides guidance for enrichment activities for students who are above grade level proficiency:
 - A reading assignment, “*What is Electric Current?*” provides an extension that develops the elements of the DCI (Lesson 8, TE).
 - An extension designed to further develop the SEP of Planning and Carrying Out Investigations is provided in Lesson 10. “Consider asking these students to design an additional experiment as home learning to answer the following question: When we change the distance between two charged objects, do the electrical forces get stronger?” These students have to turn in a hypothesis, a set of procedures, a list of materials, and a prediction about the results (TE, page 199).
 - Ideas for expanding on the CCC of Cause and Effect are provided in Lesson 11: “For students who have met and exceeded the performance expectation, ask them to include what they have learned about electron motion in a wire in the Cause-effect chain; they can modify the handout to add more boxes to the chain of cause and effect” (TE, page 249).
 - More information about this enrichment pathway is given in the sections called “Additional Guidance” in Lessons 8–12 (See examples on pages 215 and 230).

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- Consider providing reading alternatives.

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

The reviewers found extensive evidence that the materials support teachers in facilitating coherent student learning experiences over time. In all lessons, students make progress towards elements of each dimension that help the student also make progress on the questions connected to the phenomena. There is also guidance to help students connect phenomena and questions across lessons.

The following examples are evidence of this criterion:

- The use of a Driving Question Board provides a structure for students to ask new questions or revise existing questions:
 - In Lesson 1, 4, 6, and 9, student questions or prior experiences with the phenomenon create a need for the students to engage throughout the materials. The Driving Question Board (DQB) provides a structured support for teachers to draw out these connections from students and use these connections to motivate student learning. Students take stock of questions on the DQB and add new questions. For example, in Lesson 4, students work in groups to write down one or two new questions they have about magnetic fields during their investigations. Students share and categorize their new questions on the DQB. The questions are used to guide the next investigation (TE, page 106). Students also revise questions on DQB. For example, in Lesson 9, students have questions about increasing the strength of the forces in the magnetic field. The teacher guides the students to go back to the DQB to revisit those questions using a round robin structure. Students revise an existing question or come up with a new one (TE, Page 215).
 - The teacher points out gaps in the current understanding in Lesson 4. For example, “from this lesson we know what a magnetic field looks like around one magnet, but this system doesn’t look like our speaker system...Our speakers have a permanent magnet and an electromagnet, both of which have magnetic fields. So we aren’t getting the full picture.” This creates a need to discover more and motivate their learning (TE, page 119).
 - Lesson 10 and 11 are investigations based on the questions students generated from Lesson 9. For example, students figure out they need to quantify forces in Lesson 10, look

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for questions on the DQB about distance, and revise the questions (TE, page 223). In Lesson 10, students go back to the questions they compile in Lesson 9 about the strength of magnetic forces (TE, page 239).

- The lessons in the unit are ordered in a way that motivates the need to find out more.
 - After Lesson 5, students realize the investigations so far don't explain what happens to the magnetic field in real life when magnets are brought closer and further apart. They need to find something else that is changing in the field when they bring two real magnets together. They make a prediction based on cause-effect thinking that leads them to the next investigation (TE, page 137).
 - Students evaluate their group model to see what additional information is needed to figure out how a speaker works. This motivates students for Lesson 7 and 8 to learn more about the source of energy and what causes the flipping orientation in the speaker (Lesson 6, TE, page 146).
 - In Lesson 2, to motivate further investigation of the coil, students write down ideas they can do to cause the coil to interact with the magnet on an exit slip. Students ideas were used to lead to the next day's activity (TE, page 72).
 - In Lesson 3, to motivate students to investigate the space around a magnet, the teacher says "We figured out that there is energy transfer between two magnets even when the space is completely empty of matter. That is weird. It's not like what we saw in the Sound unit at all! There are forces and energy transfer in completely empty space. What could be happening in the space between the magnets when they push each other away if energy is not transferring through air? Talk with a partner about what else could be happening and how we might be able to collect evidence to help us understand what is going on in that space between two magnets" (TE, page 91).
 - Students identify gaps in what they know by putting question marks on parts of the consensus model that they need to find out more about. The teacher asks, "what else do we need to know in order to explain the speaker?" (TE, Lesson 6, page 150).
 - In Lesson 6, students brainstorm ideas about "what changes we need to make this system of two magnets to get the effect we would expect if energy transfers" on an exit slip. Students also need to use cause-and-effect language to articulate their ideas (TE, page 152).
- The cause-effect relationship is used to help students make sense of phenomena throughout the unit. For example, in Lesson 1, students use the structure "when we...we observe..." to generate questions; in Lesson 2 students use "when we...we will observe" to make predictions; in Lesson 3 students frame hypotheses using the frame "if...then; when we...we will observe..." (TE, page 53) In Lesson 6 students continue to use the cause-and-effect relationship to identify what they need to investigate about energy in a magnetic field. "What do I need to do with those magnets, a cause, to get energy to transfer into them?" (Teacher Edition, page 153). This is a strong example showing how students are using the Crosscutting Concept thinking to connect their learning and guide their questions.

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- The Progress Tracker (referenced in Lessons 1, 2, 4, 6, and 9) provides opportunities for students to independently record what they figure out and reflect their learning in their notebook and then collaboratively as a class with the class level entries reflect class-level learning.
- The Teacher Handbook is a valuable resource that goes over the elements of the five routines: Anchoring Phenomenon Routine, Navigation Routine, Investigation Routine, Putting Pieces Together Routine, and Problematizing Routine. There are supports for how to use the Driving Question Board with routines and support for using the anchoring phenomenon.

Suggestions for Improvement

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

The reviewers found adequate **evidence** that the materials support teachers in helping students engage in the practices as needed and gradually adjust supports over time. 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 an understanding and proficiency in the SEP elements over the course of the unit.

Evidence for this rating includes:

- The unit presents a strong example of how the SEP of Planning and Carrying Investigation is scaffolded over time and how the students gradually have more independence designing their own investigations.
 - In Lesson 3, students plan and conduct an investigation through two whole-class investigations. The class develops a consensus hypothesis together and collects evidence as they observe the teacher’s demonstration. In Lesson 7, students now have the opportunity to develop their hypotheses in small groups and come up with their plan to test their prediction (TE, page 164). Students are also reminded about their experience in ELA to use an argument template to make a claim followed by supporting evidence and reasoning, counterclaims or rebuttals, and a conclusion. Additional open-ended prompts are also provided (TE, page 167). In Lesson 11, each group investigates a different factor that affects the strengths of magnetic forces between two magnets. Each group designs their own investigation, presents their findings on a poster, and records patterns and feedback for other groups during the gallery walk.
- Supports are provided to engage in the SEP of Asking Questions to build student proficiency in this practice.

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- In Lesson 1, students generate questions about the phenomenon.
- Questions are improved by using cause and effect frames.
- Student determine which questions are testable and can be used as a basis for an investigation.

Suggestions for Improvement

Consider having students be increasingly responsible to making sense of phenomena. For example, do not provide scaffolds at the end of the unit or advise teachers to only use a scaffold if needed after giving the students the opportunity to engage in sensemaking by themselves.

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

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

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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: Extensive

The reviewers found extensive evidence that the materials elicit direct, observable evidence of students using practices with core ideas and crosscutting concepts to make sense of phenomena. Formative assessments are embedded as part of learning throughout the unit and students are provided with opportunities to engage in three-dimensional learning performances that require students to use grade appropriate elements of each of the three dimensions in service of making sense of phenomenon.

The following examples are strong evidence of this criterion:

- The majority of the scenarios are rich, based on specific, real-world, puzzling events or instances, and require grade-appropriate three-dimensional performances to address.
 - Summative assessments in Lessons 6 and 12 have scenarios that are specific and real-world and encourage students to engage in sensemaking. For example, in Lesson 6, students are asked to explain how a doorbell works. Similar to trying to understand how the common object of a speaker works is trying to understand how the common object of a doorbell works.
- There are multiple varied opportunities for students to visibly demonstrate their understanding and ability to use grade-appropriate elements of the SEPs.
 - After completing an investigation, students develop an explanation to explain how changing the distance between the cart and the magnets affects the energy transferred from the magnetic field (Lesson 7, page 166, TE).
 - Students have opportunities to demonstrate their understanding through CER style writing (Lesson 3) and modeling (Lesson 6).
- There are multiple varied opportunities for students to visibly demonstrate their understanding and ability to use grade-appropriate elements of the CCCs.
 - There are several strategies to help students organize cause-effect thinking. For example, students use CCC sentence frames throughout the unit to support making predictions
 - and to support the development of questions that can be used as a basis for an investigation.

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- Students try to identify which type of objects interact with a magnet in Lesson 2. The teacher “walks around the classroom during the investigation and asks students if they notice any patterns and what additional information they need to see patterns in their data” (TE, page 68). In a Building Understandings discussion, students determine that the patterns noticed during the interactions between magnets (effect) are the result of forces (cause).
- In Lesson 4, the teacher assesses students’ understanding of patterns by reading student responses in their notebook. Students use patterns in their data to describe patterns of the compass needles. If students are struggling to explain how they use patterns to help them figure out the magnetic field, additional scaffold and suggestions for intervention are provided for the teacher. (TE, page 111).
- Students figure out how a doorbell works in Lesson 6. “In the first row of the table below, write a hypothesis that describes the cause-effect relationship you would expect if there was no magnet in the doorbell, just metal like iron. In the second row, write a hypothesis that describes the cause-effect relationship you would expect if there was a magnet in the doorbell.” Students are showing whether they understand how permanent magnet creates a force and how an electromagnet works. (Teacher Guide, 155)
- The teacher evaluates students' ability to obtain scientific information and cause-and-effect relationships using a class checklist to determine whether students are meeting these scientific practices and crosscutting concepts. It is recommended to not display the checklist publicly, rather it is a tool for students to monitor and record their assessment. (TE, page 29)
- There are multiple varied opportunities for students to visibly demonstrate their understanding and ability to use grade-appropriate elements of the DCIs.
 - Students express their understanding of the magnetic field through group discussion, self-reflection, argumentative writing, and modeling.
- Tasks regularly require students to use all three dimensions together to sense-make and the vast majority of tasks are focused on sense-making (in contrast to representing or communicating previously learned material without applying it to a phenomenon or problem). Tasks do this by requiring student reasoning: to connect their existing understanding and abilities (assumed, based on the target of the assessment) to new information (provided by the scenario or previous investigations) to construct new understanding of the scenario presented—and thus demonstrate knowledge-in-use
 - The summative midpoint assessment in Lesson 6 (Figuring out the doorbell) requires students to transfer their knowledge to a new setting. They apply what they have learned about the speaker to describe how a doorbell works.
- Formative tasks are multi-dimensional:
 - In Lesson 4 pages 103–104, students **develop an explanation** of the **distribution of iron filings around a magnet**. Teacher prompts ask students to consider the **pattern and the cause of the pattern**.

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- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).
- Patterns can be used to identify cause-and-effect relationships
- In Lesson 7, page 166, students develop an explanation of the results of an investigation. They use the patterns observed in their data and the data of classmates to trace the transfer of energy in the system.
 - Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
 - Graphs, charts, and images can be used to identify patterns in data.
 - When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.
- Tasks use a variety of ways for students to express their understanding of the science ideas:
 - Class discussions such as Building Understanding Discussions and Consensus Discussions
 - Individual efforts involving drawing and writing - Exit Tickets
 - Individual writing in Progress Tracker.

Suggestions for Improvement

- Consider providing more examples of student work to show different ways of demonstrating student ways of thinking.

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

Rating for Criterion III.B. Formative: Extensive

The reviewers found extensive evidence that the materials embed formative assessment processes throughout that evaluate student learning and inform instruction. The Teacher Edition includes explicit, frequent, and varied support for formative assessment processes and attends to equity by providing support for different learners. Teachers are provided strategies for adjusting instruction based on formative assessment results. Formative assessments take varied forms, and are frequently built directly into instructional sequences. Assessments reflect grade appropriate DCIs, SEPS and CCCs.

The following examples are strong evidence of this criterion:

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- The Assessment System Overview provides a detailed outline of the purpose of each assessment in the unit (Teacher’s Edition pages 18–31). The overview shows where opportunities for formative assessment occur, what to look for in student responses, and what to do with the results of the formative assessment.
- The unit contains multiple formative assessment tasks designed to assess multiple dimensions. Some examples are listed below:
 - The Progress Tracker can be used to keep track of student learning throughout the unit. It is suggested that teachers can use the tracker to formatively assess individual student progress, and that it should not be graded.
 - There are embedded formative assessment opportunities for every lesson that are highlighted in the Assessment System Overview (TE, pages 18–31).
 - In Lesson 7 (described on page 20, TE) students develop a hypothesis for the investigation and then develop investigation plans. Students use their understanding of how cause and effect relationships can be used to make a prediction and then how the prediction can be used to develop a hypothesis. In developing the investigation plan, students use their understanding of independent, dependent, and control variables. Teachers are given guidance on what to look for in student work and what feedback to give to students.
 - Exit tickets are used as formative assessment opportunities throughout the unit. For example, in Lesson 2, the teacher uses the exit ticket to determine students’ understanding of using cause-effect relationships to justify their claim. Intervention and additional guidance are also suggested.
- Guidance is provided to teachers regarding how these formative assessments could be utilized to adjust instruction. Some examples include:
 - The teacher listens to students’ predictions about what will happen when the coil of wire is connected to the battery (Lesson 2, page 74, TE). If many students think vibration is moving through the wire, the teacher uses this opportunity to frame the discussion around two competing explanations with a T-Chart. Additional guidance is given about what investigation the students can do to verify the alternative explanation. A Building Understanding Discussion occurs after students have investigated the coil and the magnet in Lesson 2. Teachers are given guidance for what to do if students need an additional activity to build the understanding of directionality (page 23). “Consider using the following kinesthetic activity to reinforce the idea of directionality. Have students stand in pairs facing each other. Each pair should choose which student will be the coil connected to the battery and which student will be the magnet. Then ask students to hold up their arms straight toward one another with their hands almost touching and imagine what would happen if they pulled on each other (if you feel comfortable asking your students to gently pull on each other, do so). Did they move toward each other or away? Is this indicative of attraction or repulsion? Do the same exercise for students pushing on

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each other. Finish by discussing with students how this model works well as an analogy to the wire and magnet system (pushes and pulls bringing things apart and together) and how the model falls short (contact forces versus forces at a distance).”

- Students revise their questions using Cause and Effect sentence frames in Lesson 9 (page 207, TE). Teachers are provided with information about assisting students who are struggling with this task. The suggestions for assistance do not bring the students to a grade level use of the CCC.

Suggestions for Improvement

N/A

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**

The reviewers found adequate evidence of included rubrics and scoring guidelines that help the teachers interpret student performance for all three dimensions. Assessment targets—for all dimensions being assessed—are clearly stated and incorporated into the scoring guidance. Guidance is provided for teachers to interpret student progress toward the targeted three-dimensional learning performances. Major assessment opportunities, including exit tickets, major formative assessment opportunities, and all summative assessments include scoring guidance for teachers and students.

The following examples are evidence of this criterion:

- The materials include a key for the summative assessment after Lesson 6 (pages 155–158). Information about assigning point values to the answers is given.
- In Lesson 9, a three-dimensional rubric for the model is provided (Teacher Guide, page 217).
- A scoring guide and sample responses are provided for the summative transfer task (TE, Lesson 12, page 261).
- The Lesson-by-Lesson Assessment Opportunities table (pages 22–31) and Assessment Opportunity call-outs within the lessons (e.g., lesson 1, page 53) often include guidance on what to look/listen for and what to do for all three dimensions.

Suggestions for Improvement

- Consider clearly incorporating assessment targets into the scoring guidance for all dimensions being assessed and their use together.
- Consider including a range of student responses and interpretation guidance to support score interpretation. Examples are provided (such as in Lesson 6, TE page 156). For open response

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questions, it is helpful to have a scoring rubric with sample student responses for each rating category (emerging, developing, proficient, excelling). A rubric is provided to evaluate student generated models that have been revised several times in Lesson 9, page 217. Consider showing examples of student work to help teachers determine the difference between the categories of “Missing”, “Developing”, and “Mastered.”

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**

The reviewers found adequate evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples because the materials use developmentally appropriate text, provide tasks that do not assume all students know culturally-specific knowledge and use a variety of modalities to collect information from students. Vocabulary used throughout the unit is appropriate.

The following examples are evidence of this criterion:

- Vocabulary (science and non-science) is grade-level appropriate and the amount of text in tasks/items is grade appropriate.
 - The developers provide an overview of their philosophy on the development of science vocabulary on pages 51–52 of the Teacher Handbook. “Once ALL students have developed a conceptual understanding of an idea in a lesson, introducing a relevant scientific term as a shorthand way to reference that idea makes complete sense. It is simply a matter of timing and where we want them focusing their intellectual work.”
 - Guidance is provided to the teacher in regard to instructional strategies to assist students who may struggle with vocabulary. “Continue to encourage students to use both everyday and scientific vocabulary by asking questions to probe their ideas. For example, if a student says that something sticks to a magnet or is attracted to a magnet, ask the student, are you saying that the object is being pulled toward the magnet or the object is being pushed away from it?” (Lesson 2, page 68, TE).
 - The student handouts are grade-appropriate and accessible for all students.
 - Text is used to reinforce ideas and to provide extensions of learning (Magnetic Levitation Trains). **However, the reading level of some texts is below grade level.**
- Although activities throughout the unit capitalize on the knowledge that students bring to the classroom, **the assessment materials may not require students to make connections to their lives beyond the classroom.**
 - Throughout the lessons, students are provided with opportunities to express their own

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ideas and bring their experiences to the rest of the class. Students are encouraged to share home learning experiences (exploring the magnet at home, magnet in another language, researching an electromagnetic device with a family member or a librarian)

- These real-life experiences are not routinely used as scenarios in the assessments.
- Students express their understanding of science ideas in a variety of ways:
 - Partner talk, small group discussions and whole class discussions
 - Individual and group production of models, using pictures and words
 - More formal written explanations and other demonstrations of student understanding.

Suggestions for Improvement

- Consider linking scenarios in the assessment materials to students experiences outside the classroom.
- Although the formative assessment tasks allow students to express their ideas in multiple modalities, the summative assessments have students use only words and pictures to express their understanding. Consider allowing additional modalities for the summative assessments.

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**

The reviewers found extensive evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning. There are multiple assessment opportunities that allow all students to demonstrate their understanding of the same learning goals in a variety of ways.

The following examples are strong evidence of this criterion:

- The materials include an Assessment System Overview, which provides a detailed outline of the various assessments and which includes the purpose of the assessment and what to look for in student responses (Teacher’s Edition pages 18–31).
- Pre-Assessments
 - The materials discuss how to use the student responses in Lesson 1 as an informal pre-assessment (page 18, TE). “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. Specifically, look for students’ initial understanding of modeling, asking questions, systems and systems models, and cause & effect.” The student work referenced includes initial models and questions for the DQB.

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- Self-Assessments
 - Self-assessment tools include the rubric “Self-Evaluation: Engaging in Classroom Discourse” (page 54, Teacher Handbook), “Self-Assessment: Giving Feedback”, “Self Assessment: Receiving Feedback” (both on page 57, Teacher Handbook). In the Assessment System Overview (pages 17–19, TE), the guidance is given that: “The student self-assessment discussion rubric can be used anytime after a discussion to help students reflect on their participation in the class that day. Choose to use this at least once a week or once every other week.” The overview also suggests using self-assessment rubrics after completing substantial work.
 - In Lessons 1 and 5, the students share their individual models and then they develop a record of what they agree on and where they have competing ideas. Students evaluate their own model as they listen to their peers share: “if something is similar, place a small checkmark near what is similar on your own model; if something is different, place a question mark near what is different on your own model.” Through this process, the class reaches a consensus model (Lesson 1, Slide K) (Lesson 5, Slide F).
 - The Progress Tracker provides an opportunity to reflect and evaluate on students’ learning. For example, when the class develops ideas together and comes to agreement, students record it as evidence in their progress tracker (TE, page 72).
- Opportunities for Formative Assessment are detailed in IIIB.
- Summative Assessment:
 - Lesson 12: students choose an electromagnet application from the class list and apply their understanding of how energy, force, and magnets work together. This transfer task gives students an opportunity to integrate all three dimensions as they develop a model to explain how their device works. They have to explain how forces are acting at a distance and describe the cause and effect relationships that allow the device to work. (TE, page 261)
- Progress Tracker
 - “The Progress Tracker is a thinking tool that was designed to help students keep track of important discoveries that the class makes while investigating phenomena and figure out how to prioritize and use those discoveries to develop a model to explain phenomena. It is important that what the students write in the Progress Tracker reflects their own thinking at that particular moment in time. In this way, the Progress Tracker can be used to formatively assess individual student progress or for students to assess their own understanding throughout the unit. Because the Progress Tracker is meant to be a thinking tool for kids, we strongly suggest it is not collected for a summative “grade” other than for completion” (Teacher’s Edition, page 18).

Suggestions for Improvement

N/A

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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

The reviewers found extensive evidence that the materials provide multiple opportunities for students to demonstrate the performance of practices connected with their understanding of core ideas and crosscutting concepts because there are multiple, linked student performances that provide students with several opportunities to demonstrate understanding. The teacher and students are engaged in multiple modalities of feedback and written and oral feedback is provided in a timely fashion from teacher and peers. Students are provided opportunities to utilize feedback to construct new learning.

The following examples are strong evidence of this criterion:

- Throughout the unit, students have multiple opportunities to demonstrate that they have met learning goals.
 - Three key learning goals are identified for this unit and expressed in the Performance Expectations.
 - Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
 - Conduct an investigation and evaluate experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
 - Develop a model to describe that when the arrangement of objects interacting at a difference changes, different amounts of potential energy are stored in the system.
 - Students show they have met these learning goals in a variety of ways. These have been documented in detail through this review.
 - Modeling and writing activities in their student notebooks
 - Responding to questions in the Student Edition
 - Participating in partner talk and small group discussions
 - Participating in whole-class discussions with different formats
 - Expressing individual understanding on exit tickets
 - Demonstrating understanding on two summative assessments
- The students engage in peer and teacher feedback to construct new learning.
 - Students revise the model from Lesson 6 in Lesson 9. They first build individual models then share their ideas in small groups, then the whole class discusses how to put these pieces together. As students revise their model, they use different colors or labels to indicate which parts of the model are new or add new post-it notes (TE, page 208).

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- Students receive peer-written feedback on their procedure using an Investigation Plan Rubric (Lesson 11, Slide F). They also leave feedback for other groups by identifying what’s interesting, confusing, and patterns in the data during the gallery walk (Lesson 11, Slide K). They use the feedback to improve their investigation plan.
- Individual student work receives teacher feedback at several points in the unit. The places where teacher feedback is appropriate and some examples of teacher feedback are provided in the Assessment System Overview.
 - On page 20 (TE), students develop a hypothesis for an investigation and record this in their notebook. Teachers are guided to provide feedback in the form of noticing and wonderings. Sample feedback is included.
 - Another example of teacher feedback occurs when students modify their models in their notebooks (page 29, TE). Teachers use the Rubric for Model in Lesson 9 to structure feedback to students.
 - In Lesson 8, students develop their questions for investigation. For students who struggle, the teacher “leaves sticky notes in their notebook asking them to record new questions.” The teacher collects the questions to add to the DQB (TE, page 28).

Suggestions for Improvement

N/A

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

Unit Scoring Guide – 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

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Overall Score

Category I: NGSS 3D Design Score (0, 1, 2, 3):

Category II: NGSS Instructional Supports Score (0, 1, 2, 3):

Category III: Monitoring NGSS Student Progress Score (0, 1, 2, 3):

Total Score:

Overall Score (E, E/I, R, N):

Scoring Guides for Each Category
<p>Unit Scoring Guide</p> <p>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)</p> <p>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</p> <p>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</p>

Overall Scoring Guide
<p>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)</p> <p>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)</p> <p>R: Revision needed—Partially designed for the NGSS, but needs significant revision in one or more categories (total ~3–5)</p> <p>N: Not ready to review—Not designed for the NGSS; does not meet criteria (total 0–2)</p>