EQuIP RUBRIC FOR SCIENCE EVALUATION

Why does an object's motion change?

Developer: OpenSciEd

Grade 4 | July 2024

equip
Educators Evaluating Quality Instructional Products

nsta
National Science Teaching Association

CATEGORY I Rating			CATEGORY II Rating			CATEGORY III Rating		
A.	Explaining Phenomena/ Designing Solutions	**Extensive**	**A.**	Relevance and Authenticity	**Extensive**	**A.**	Monitoring 3D Student Performance	**Extensive**
B.	Three Dimensions	**Extensive**	**B.**	Student Ideas	**Extensive**	**B.**	Formative	**Extensive**
C.	Integrating the Three Dimensions	**Extensive**	**C.**	Building Progressions	**Extensive**	**C.**	Scoring Guidance	**Extensive**
D.	Unit Coherence	**Extensive**	**D.**	Scientific Accuracy	**Extensive**	**D.**	Unbiased Tasks/ Items	**Extensive**
E.	Multiple Science Domains	**Extensive**	**E.**	Differentiated Instruction	**Adequate**	**E.**	Coherent Assessment System	**Extensive**
F.	Math and ELA	**Extensive**	**F.**	Teacher Support for Unit Coherence	**Extensive**	**F.**	Opportunity to Learn	**Adequate**
			G.	Scaffolded Differentiation Over Time	**Adequate**			
	SCORE CAT I	**3**		**SCORE CAT II**	**3**		**SCORE CAT III**	**3**
				SUM CATEGORIES	**9**			
				RATING	**E**			

Summary Comments

This unit is strong in several areas, including these:

- The anchoring phenomenon is relevant to students and presented in various ways. Students experience the phenomenon of the movement of a kicked ball through video, slow motion video, and outdoor experiences with kicking a soccer ball. Lesson-level phenomena are also experienced firsthand by students.
- The unit uses and develops elements of all three dimensions. Specific elements of each of the dimensions are present in several lessons, giving students ample opportunities to develop proficiency in their skills and understanding. These include the Disciplinary Core Ideas of PS3.A—Definitions of Energy, PS3.B—Conservation of Energy and Energy Transfer, and PS3.C—Relationship Between Energy and Forces. The materials provide opportunities to develop and use specific elements of these SEPs: Asking Questions and Defining Problems, Constructing Explanations and Designing Solutions, and Planning and Carrying Out Investigations. The materials provide opportunities to develop and use specific elements of the CCCs of Cause and Effect, Energy and Matter, and Patterns.
- Elements that have been emphasized in the lessons are present in the many formative and summative assessments, allowing for evaluation of student progress.
- Teachers are provided with an understanding of the prior learning in all the dimensions that are the focus of the unit. There is documentation of how each of the focal elements builds on prior learning with the goal of having students become proficient in the unit's learning targets.
- A navigation routine connects the lessons. Students see that their questions guide the instruction as they generate questions about the phenomenon, then seek answers to those questions. Teachers are provided with strategies to guide students and connect lessons.
- The unit gives teachers a comprehensive assessment system. Assessments state the learning goals being addressed and also include strategies for teachers on specific ideas they should look for in student work. They also provide teachers with suggestions on how to respond to student thinking.

During revisions, the reviewers recommend paying close attention to the following areas:

- Although some differentiation strategies are included, there is a lack of specific guidance on tasks that may be new or difficult for students. The Elementary Teacher Handbook contains information on how to meet the needs of a variety of learners, yet that resource is not referenced in the unit lessons. There are no supports for students who have already met the performance expectations.
- Strategies for providing feedback are found throughout the unit, but guidance about providing feedback to individual students is lacking. When class discussions are intended to lead to student understanding, there is little follow-up to determine individual students' thinking. The one place for students to express their own thoughts, writing in the My Growing Ideas chart, is not used as a place where teachers can evaluate individual student thinking and provide feedback.

Please note that in the feedback provided in this report, black text indicates either neutral comments or evidence that the criterion was met. Purple text signifies evidence that does not support the claim that the criterion was met. The purple text in these reports is specifically related to the criteria and aims to highlight areas with potential for improvement. It is important to note that *not all purple text affects the score or rating*; much of it is too minor to impact the overall rating. For instance, even criteria rated as "Extensive" may contain purple text intended to aid in continuous improvement processes. In such cases, the criterion was indeed met, and the purple text is simply not part of the justification for the "Extensive" rating.

CATEGORY I
NGSS 3D Design

I.A. Explaining Phenomena/Designing Solutions

I.B. Three Dimensions

I.C. Integrating the Three Dimensions

I.D. Unit Coherence

I.E. Multiple Science Domains

I.F. Math and ELA

I.A. EXPLAINING PHENOMENA / DESIGNING SOLUTIONS — Extensive

Making sense of phenomena and/or designing solutions to a problem drive student learning.

i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving.
ii. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems.
iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.

The reviewers found extensive evidence that making sense of phenomena drives student learning. Materials are organized so that students are figuring out the central phenomenon: What causes the changes of motion in a kicked soccer ball? Student questions and prior experiences related to the phenomenon motivate sensemaking. Related evidence includes the following:

i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem-solving.
The materials are organized so that students directly experience the phenomenon, followed by learning where students make sense of that phenomenon. Students regularly return to the phenomena or problems to add layers of explanation, iterate on solutions based on learning, or build on what they have learned from smaller phenomena or problems to explain a broader science topic.

- In Lesson 1, Synthesize Section, "Identify the anchor phenomenon for this unit. To transition to the Synthesize, tell students that when they shared what they saw, heard, and felt, you noticed that they identified a phenomenon. Remind students that a phenomenon is something that happens, like a soccer ball moving across a field. Based on the class Notice and Wonder chart, students observed that a soccer ball moves differently with different kicks and on different surfaces. When scientists are trying to figure out what causes a phenomenon, they will often draw a model of it." (Lesson 1, Teacher Edition)
- In Lesson 6, Navigate Section, Step 1, "Connect what we learned in our last lesson to what we are wondering about now. Display slide A and have students look at their filled out My Growing Ideas from Lesson 5. Ask students to briefly share what they figured out about how the size of a kick affects the distance a ball moves...Ask students how we could reuse our Kick Investigation System to test how a kick is like other collisions." (Lesson 6, Teacher Edition)

Student questions drive the learning in the unit. At times, students consider prior experiences and how those experiences may help them understand the phenomenon.

- In Lesson 1, Explore Section, Step 2, "Give instructions for going outside (or to the gym). Tell students we are going to go outside and observe what we see, hear, and feel when a soccer ball moves. We are making observations to build on the ideas we just discussed. Remind students that to observe means to notice details. Today, we will be observing what we can see, hear, and feel about how a soccer ball moves. Recall a few examples from the Connect about what students saw, heard, and felt. Facilitate a 1- to 2-minute discussion with students about previous experiences with a soccer ball and what they might see, hear, and feel when they go outside (or to the gym) to observe how a soccer ball moves." (Lesson 1, Teacher Guide) Students' prior experiences related to how soccer balls move when kicked help to create a need to investigate more about how a soccer ball moves.

- Lesson 4, Navigate section, Step 1: "Identify DQB questions related to what we are wondering about in this lesson. Display slide B. Remind students that we left our last investigation wondering how we can test what keeps a ball moving on its own. Distribute 1-2 questions from the DQB to student pairs, then ask students to turn and talk with a partner about the prompt on the slide" (Lesson 4, Teacher Edition).
- In Lesson 9, Navigate Section, Step 5, "Revisit our Driving Questions Board. Display slide F. Remove several questions from the DQB, enough to give each group at least one question to discuss, possibly more if you want. Distribute questions from the DQB to each group. Each group should discuss their question(s) and be ready to sort them into one of three categories; answered, partially answered, or still need to be answered. Ask each group to share their question and their response, and invite the class to agree or disagree with that group's reasoning. As the class comes to a consensus on which questions have been answered or not, have them reattach the questions to the board in those categories. Prompt students to ask more questions. Display slide G. Remind students that all of our learning so far has been focused on the evidence of energy transfer that we observed in our investigations and that we started our learning by identifying things we noticed and wondered about a soccer ball's changing motion. Direct students to look over our Notice and Wonder chart from Lesson 1, our Ideas for Investigations, and our Driving Question Board. Facilitate a brief discussion about how the ideas on our chart relate to what we have figured out so far." (Lesson 9, Teacher Guide)
- Lesson 10, Navigate Section, Step 7, "Emphasize that we have not yet explained why the drum felt warmer where it was hit with the pedal. Encourage students to place questions on the DQB that they are wondering about concerning warmth. Suggest that we explore more about those questions next time." (Lesson 10, Teacher Guide)
- Lesson 11, Navigate Section, Step 7, "Take stock of what we have figured out and what questions we still have. Display Slide P. As a class, go through the remaining questions on the Driving Question Board. Quickly review with the students the answers to the questions. Determine if any questions have been left unanswered or that we can partially answer." (Lesson 11, Teacher Edition)

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

There is a close match between the phenomenon and the learning goals of the unit.

Lesson 6, "Evaluate a plan to determine if it is a fair test for investigating how the motion of two objects changes (effect) following a collision (cause). (Lesson 6, Teacher Edition)

- Lesson 6, Explore Section, Step 2, "Distribute Colliding Round Objects Investigation Plan handout to students and display slide E. Tell students that this is part of the same investigation plan as last time, but some parts need to be filled in by them. Give students a few minutes to review the handout individually and then turn and talk with a partner about what is missing and what decisions need to be made. Have a brief conversation about the work that needs to be done." (Lesson 6, Teacher Edition)

Lesson 10, "Identify the evidence that supports particular points in an explanation of objects colliding and energy being transferred to the surroundings as sound. (Lesson 10, Teacher Edition)

- Lesson 10, Explore Section, Step 3, "Continue to play the rest of the video, encouraging students to pay attention to how sound could make things move. Discuss our observations from the video...Summarize that we have figured out that sound can move objects, and that sound is evidence of energy transfer. We also noticed that a pedal or a drumstick causes a collision." (Lesson 10, Teacher Edition)

Suggestions for Improvement

- For teachers using this unit, consider customizing the lessons to reflect students' interests by adding other kinds of experiences students may have with moving a ball.

I.B. Three Dimensions (All 3 dimensions must be rated at least "adequate" to mark "adequate" overall)	Extensive

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.*

Document evidence and reasoning, and evaluate whether or not there is sufficient evidence of quality for each dimension separately.

Evidence needs to be at the *element level* of the dimensions (see rubric introduction for a description of what is meant by "element")

The reviewers found extensive evidence that the materials give students opportunities to build an understanding of grade-appropriate elements of the three dimensions. Students regularly engage in elements of all three dimensions to make sense of the anchoring or lesson-level phenomenon.

Rating for Criterion: SEP Extensive	i. Provides opportunities to *develop and use* specific elements of the SEP(s).

The reviewers found extensive evidence that the materials provide opportunities to develop and use specific elements of the SEPs Asking Questions and Defining Problems, Constructing Explanations and Designing Solutions, and Planning and Carrying Out Investigations. These pieces of evidence were selected because they provide examples of when the element is developed within the claimed lesson.

AQDP: Asking Questions and Defining Problems

Claimed Element: AQDP: 4.E1 Ask questions about what would happen if a variable is changed.
Claimed in Lesson 8. Evidence was found in Lesson 8:

- Lesson 8, Navigate section, Step 1: "Develop a testable question to guide our investigation. Briefly read questions related to changing surfaces on our Driving Question Board, the testable questions we have investigated so far, and our Ideas for Investigation. As a class come up with a testable question that could guide our investigation today, something similar to "What happens to the motion of the ball if we change the surface?" (Lesson 8, Teacher Edition)

Claimed Element: AQDP: 4.E2 Identify scientific (testable) and non-scientific (non-testable) questions.
Claimed in Lessons 4 and 6. Evidence was found in Lesson 4 and Lesson 6, examples include:

- Lesson 4, Navigate section, Step 1: "Identify testable and non-testable questions on our DQB. Display slide E. Have student pairs review the questions they identified are related to what we are wondering about and determine if they are testable or not. Remind students that it is okay if they are not, because we might still

be able to gather evidence from a nonfiction book or talk to scientists to answer them. Using the prompts on the slide, have students mark the questions they think are testable." (Lesson 4, Teacher Edition).

- Lesson 6, Explore section, Step 2: "Summarize what students noticed and how they might use the frames for the testable questions to re-write their DQB questions, how they can identify the components and variables, and what they need to remember for analyzing their data. Point out to students that predictions are important, too, and we'll work on that together as a class later in this lesson. We can only make a prediction once we know what our testable question is" (Lesson 6, Teacher Edition)

Claimed Element: ADQP: 4.E3: Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.
Claimed in Lessons 2, 6, 10, 11, and 12. Evidence was found in 2, 6, 10, 11, and 12, examples include:

- Lesson 2, Synthesize Section, Step 4, "Individually record our questions. Display slide L and distribute the Questions Thinking Space handout. Explain that we have made lots of great observations about how the hockey pucks, soccer balls, and marbles move, but scientists look for questions to answer--things they want to figure out about the world. So, let's take some time to think about what we are wondering about how these objects move or change their motion." (Lesson 2, Teacher Edition)
- Lesson 6, Synthesize, Step 4: Students first develop a testable question and then make a prediction. "Make predictions of what we think will happen in our investigation. Explain that scientists often make predictions about what they will think happen in their investigation. Pause to discuss the term prediction. Ask students what they think of when they hear the word prediction. Elicit a few ideas, then share that prediction means to make a statement that something might happen or is expected to happen" (Lesson 6, Teacher Edition).
- Lesson 11, Explore Section, Step 3, "Make predictions of what we think will happen in our investigation. Display slide I. If students have not yet done so, have them jot down their investigation question on their Shake-It-Up Investigation handout. Explain that now that we have our question and know what variable we are changing and the variables that are staying the same, we should be able to predict what we think will happen. (Lesson 11, Teacher Edition)
- Lesson 10, Navigate section, Step 1: Remind students of the testable question we asked about sound. Remind students that we also created a testable question that would help us explore why we are hearing sound when a ball collides with a foot. Display slide B. Review the question with students and then use the prompts on the slide to make predictions about how and why sounds are produced in a collision. Give students 1-2 minutes to discuss with a partner before having them share their ideas with the class. Encourage students to use the "If…then…because…" sentence frame they have used in other investigations to make predictions. Jot down their predictions on a whiteboard, chart paper, or digital space for students to refer to throughout the lesson" (Lesson 10, Teacher Edition).

CEDS: Constructing Explanations and Designing Solutions

Claimed Element: CEDS: 4.E1: Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard).
Claimed in Lessons 7. Evidence was found in 7:

- Lesson 7, Synthesize Section, Step 4, "Distribute Construct an explanation about energy during a collision and ask students to write in their own words, or draw what we now know about collisions and energy transfer." (Lesson 7, Teacher Edition)

Claimed Element: CEDS: 4.E2: Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
Claimed in Lessons 3, 5, 8, 9, and 12. Evidence was found in 3, 5, 8, 9, and 12, examples include:

- Lesson 5, Synthesize Section, Step 6, "Construct an explanation to answer our investigation question. Display Slide K. Using the prompts on the slide, come to consensus with students on what we have figured out based on the evidence we collected in our fair test investigations. As they share their oral explanations, consider jotting them down on a whiteboard, chart, or digital space." (Lesson 5, Teacher Edition)
- Lesson 8, Synthesize Section, Step 4, "Construct an explanation that answers our investigation question. Display slide I. Distribute Constructing Explanations to students. Explain to students that they have enough information to explain what happens to the motion of the ball if we change the surface and that when we explain "what" questions in science, we answer them like we do "how and why questions": we need to explain what happened to the motion of the ball and why its motion changed. Encourage students to use the sentence starts to help them construct their explanations, and the Word Wall. When they are finished, collect their handouts." (Lesson 8, Teacher Edition)
- Lesson 12, Synthesize Section, Step 4, "Individually ask questions and construct explanations. Display slide F. Distribute Collisions: Graphic Question Organizer or Collisions: Written Explanation or Collisions: Comic Strip to each student. Remind students that an important part of their explanation is to use evidence to support their ideas. To provide evidence students can use their observations from their investigations, their Class Consensus Model, and their Gotta-Have-It Checklist. Point out to students that for Part A they are addressing questions about bowling." (Lesson 12, Teacher Edition)

Claimed Element: CEDS: 4.E3: Identify the evidence that supports particular points in an explanation.
Claimed in Lessons 9 and 10. Evidence was found in 9 and 10:

- Lesson 9, Synthesize section, Step 3: "Use words and drawings to construct your explanation. Use the Gotta-Have-It checklist to be sure your explanation is complete. Be sure to use evidence to support your explanation. Your evidence could be what you observed in the video, what you observed playing marbles, or what you observed in your investigations during this unit. Look at your class Gotta-Have-It Checklist. Write the letter for every idea you have included in your explanations" (Lesson 9 Handout, Model of Marble Collisions).

INV: Planning and Carrying Out Investigations

Claimed Element: INV: 4.E1: Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
Claimed in Lessons 4, 5, 6, 7, 9 and 11. Evidence was found in 4, 5, 6, 7, 9 and 11, examples include:

- Lesson 4, Synthesize Section, Step 4: "As a class, students collaborate to plan an investigation with controlled variables and multiple trials for investigating testable questions." (Lesson 6, Teacher Edition)
- Lesson 5, Explore Section, Step 2, "Organize students in small groups of 3-4 students, possibly the same groups they worked in to plan this investigation in Lesson 4. Give logistical directions for how we are using space in the classroom and how to collect materials. Distribute Kick System Data to students and review how they will collect their data. Direct small groups to carry out the investigation. Present slide C. Within each group, assign or have students choose which size kick they will test (either tap, small, medium, or large) and fill out their data table accordingly. (Lesson 5, Teacher Edition)
- Lesson 7, Explore Section, Step 2, "Direct students to get into the groups they planned their investigation with, and distribute Kick Investigation Data. Assign who will do each kick size. Remind students that they are in charge of filling out the data table for the kick and trials they are assigned. Students may find it helpful to write their name next to the row they are assigned. Distribute any other necessary materials to students and give them time to complete their investigation." (Lesson 7, Teacher Edition)
- Lesson 9, Synthesize section, Step 3: Students compare two investigation plans. "Why is the investigation you chose going to better help a class understand how a marble launcher can push marbles farther? In your

explanation, be sure to include 1) the variables, and 2) and how the plan helps the class investigate how force of the launch is related to a marble's speed" (Lesson 9 Handout, Model of Marble Collisions)

Claimed Element: INV: 4.E2: Evaluate appropriate methods and/or tools for collecting data.
Claimed in Lessons 6, 10, and 11. Evidence was found in 6, 10 and 11, examples include:

- Lesson 11, Explore section, Step 3: "Evaluate an investigation plan to determine if it is a fair test. Display slide G. Distribute one Shake-It-Up Investigation handout to students as you explain that you have an idea for an investigation they could do, but you would like their help to complete it. Give groups time to review the handout and compare it to the Fair Test Investigation Infographic" (Lesson 11, Teacher Edition).

Claimed Element: INV: 4.E3: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
Claimed in Lessons 2, 3, and 9. Evidence was found in 2 and 3, examples include:

- Lesson 3, Explore Section, Step 2, "Turn and talk about observations. Display slide D. Have students turn to a partner to discuss what they observed, each taking a turn to share. Encourage students to add observations to their handout based on what they heard from their partner." (Lesson 3, Teacher Edition)
- Lesson 9, Synthesize section, Step 3: Students compare two investigation plans and then develop an explanation, but they do not make observations or measurements.

Claimed Element: INV: 4.E4 Make predictions about what would happen if a variable changes.
Claimed in Lesson 8. Evidence was found in Lesson 8:

- Lesson 8, Explore section, Step 2: "What do you predict will happen when we change the variable of the surface the ball rolls on?" (Lesson 8, Teacher Edition).

Criterion-Based Suggestions for Improvement: NA

Rating for Criterion: DCI Extensive	ii. Provides opportunities to develop and use specific elements of the DCI(s).

The reviewers found extensive evidence that the materials provide opportunities to develop and use specific elements of PS3.A—Definitions of Energy, PS3.B—Conservation of Energy and Energy Transfer, and PS3.C—Relationship Between Energy and Forces. These pieces of evidence were selected because they provide examples of when the claimed elements are developed in the lessons.

PS3.A: Definitions of Energy

Claimed Element: PS3.A.1: Definition of Energy: The faster a given object is moving, the more energy it possesses.
Claimed in Lessons 1, 2, 7, 8, 9, 10, and 12. Evidence was found in claimed lessons 1, 2, 7, 8, 9, 10, and 12, examples include:

- Lesson 1, synthesize section, Step 3: Students are prompted with several questions as they draw their initial model. "How would you describe the ball's motion (how it was moving) before you kicked it? What caused the ball to start moving? What was the effect of kicking the ball? How did the ball move after you kicked it?

How did the ball's motion change as it rolled along the ground? What caused the ball to slow down? What caused the ball to stop moving?" (Lesson 1, Teacher Edition)

- Lesson 7, Synthesize Section, Step 4: The teacher begins the discussion asking students to discuss with a small group or partner the making sense questions on Slide G. Then the teacher is guided to "Emphasize to students that the changes in motion they are describing are evidence of energy transfer. Then, ask students to consider where the energy came from, where the energy went, and how we can tell how much energy something has. To help guide students through this discussion, you can use the Kick Investigation System. Push for students to identify the evidence that supports their responses." (Lesson 7, Teacher Guide) There are prompts for the teacher to use to support students in sharing what they have made sense of with their partner or small group.
- Lesson 8, Synthesize section, Step 3: "How is the speed of the ball related to the energy of the ball? The ball slows down because it has less energy. A faster ball has more energy than a slower ball. A faster ball has more energy to transfer than a slower ball" (Lesson 8, Teacher Edition).
- Lesson 9, Synthesize Section, Step 2, "Organize students into a Scientists' Circle. Point out that the class has figured out several important ideas about forces and energy transfer that can help explain changes in the motion of a soccer ball." (Lesson 9, Teacher Guide)

Claimed Element: PS3.A.2 Definition of Energy: Energy can be moved from place to place by moving objects or through sound, light, or electric currents.
Claimed in Lessons 6, 7, 10, and 12. Evidence was found in lessons 6, 7, 10, and 12, examples include.

- Lesson 10, Explore section, Step 3: Students watch a video and conclude. "Yes, sound can make something move. We saw the sound from the drum make the sprinkles move even though they are not touching" (Lesson 10, Teacher Edition).
- Lesson 12, Synthesize section, Step 2: Students recognize energy transfer and include those ideas on the checklist. "Heat is evidence of energy transfer. When there is a collision, sound is transferred to the surroundings. Heat is transferred to the surroundings in a collision. A ball slows down and stops on all surfaces because it transfers its energy to the surface and to the surroundings as heat and sound" (Lesson 12, Teacher Edition)

PS3.B Conservation of Energy and Energy Transfer

Claimed Element: PS3.B.1 Conservation of Energy and Energy Transfer: Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2), (4-PS3-3)
Claimed in Lessons 6, 7, 10, 11, and 12. Evidence was found in claimed lessons 6, 7, 10, 11, and 12, examples include

- Lesson 6, Navigate Section, Step 1, "Ask students to briefly share what they figured out about how the size of a kick affects the distance a ball moves. Then, prompt students to consider other parts of the kick investigation system and what happened after the collision and why. Encourage students to practice using force, energy, energy transfer, and collisions in their responses." (Lesson 6, Teacher Edition)
- Lesson 7, Synthesize Section, Step 4, "Share our observations of what happened to the kicked ball. Invite students to share what patterns they observed about the motion of the kicked ball (question #4 on their handout). As they share, emphasize changes in motion that you hear students describe, such as slowing down or coming to a stop after the collision. Students may also reference the box on the back of their handout where they wrote down other observations that they made about the balls' motion." (Lesson 7, Teacher Edition)

- Lesson 10, Explore Section, Step 2, "Explain that you also have line plot data that the class created to help them visualize patterns. Display the line plot data on slides F-J. Use the following prompts to analyze and interpret the data with the class." (Lesson 10, Teacher Edition) Students figure out that energy is transferred as sound when they observe patterns in data that suggest the harder the collision, the louder the sound that is produced.
- Lesson 11, Synthesize Section, Step 6, "Come to a consensus that we should feel heat everywhere we have marked a collision: where the foot makes contact with the ball, where the ball rolls on the ground, and where the foot stops the ball. Then, point to the 'contact force with grass.' Review with students that we already know that the ball transfers energy to the grass and to the surroundings as sound. Both cause the ball to slow down. We have just named that heat could be present there, too. Ask students why a ball slows down and stops on its own. Reach an agreement that the ball transfers its energy to the grass, and to the surroundings as sound and heat." (Lesson 6, Teacher Edition)
- Lesson 12, Synthesize Section, Step 4, "Individually ask questions and construct explanations. Display slide F. Distribute Collisions: Graphic Question Organizer or Collisions: Written Explanation or Collisions: Comic Strip to each student. Remind students that an important part of their explanation is to use evidence to support their ideas." (Lesson 12, Teacher Edition) Students use the idea that a moving object has energy, and when objects collide, energy can be transferred from one object to another when constructing their explanation and identifying where energy is present and what their evidence is.

PS3.C Relationship Between Energy and Forces

Claimed Element: PS3.C.1 Relationship Between Energy and Forces: When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3)
Claimed in Lessons: 1, 2, 3, 4, 5, 6, 7, 8, 9, and 12. Evidence was found in claimed lessons 1, 2, 3, 4, 5, 7, 8, 9, and 12, examples include

- Lesson 3, Synthesize Section, Step 3, "Explain that there is a science word that means exactly what we are talking about here: this kind of kick or hit where two objects (like a foot and a ball) come together with force is called a collision. A collision is an example of a contact force. Add "collision" to the Word Wall, then continue to build the model." (Lesson 3, Teacher Guide)
- In Lesson 4, Synthesize Section, Step 4, the class discusses how to test the size of a kick (force).
- In Lesson 5, Synthesize Section, Step 6, "Revise our Class Consensus Model. Present slide L. Remind students that we started talking about collisions in Lesson 3 and we created our Class Consensus Model to think about how the foot was colliding with the ball. Use the model to introduce key questions to help us think about energy transfer. Write "Where does the energy come from?" and 'Where does the energy go?'" (Lesson 5, Teacher Edition)
- In Lesson 7, Synthesize Section, Step 4, "Then, ask students to consider where the energy came from, where the energy went, and how we can tell how much energy something has. To help guide students through this discussion, you can use the Kick Investigation System. Push for students to identify the evidence that supports their responses." (Lesson 7, Teacher Edition)
- In Lesson 8, Synthesize Section, Step 4, Students answer the following questions: "How should we describe the interaction (collision) between the ball and the grass?" and What evidence do we have that the ball is transferring energy to the grass?" (Lesson 8, Teacher Edition)

Criterion-Based Suggestions for Improvement: NA

Rating for Criterion: CCC Extensive	iii. Provides opportunities to *develop and use* specific elements of the CCC(s).

The reviewers found extensive evidence that the materials provide opportunities to develop and use specific elements of the CCCs of Cause and Effect, Energy and Matter, and Patterns. These pieces of evidence were selected because they provide examples of when the claimed elements are developed in the lessons.

CE: Cause and Effect

Claimed Element: CE: 4E1 Cause and effect relationships are routinely identified, tested, and used to explain change.
Claimed in Lessons 1, 2, 3, 5, 6, 7, 8, and 12. Evidence was found in Lessons 1, 2, 3, 5, 6, 7, 8, and 12.

- Lesson 1, synthesize section, Step 3: Students are prompted with several questions as they draw their initial model. "How would you describe the ball's motion (how it was moving) before you kicked it? What caused the ball to start moving? What was the effect of kicking the ball? How did the ball move after you kicked it? How did the ball's motion change as it rolled along the ground? What caused the ball to slow down? What caused the ball to stop moving?" (Lesson 1, Teacher Edition)
- Lesson 2, Synthesize section, Step 4: Students consider cause and effect when writing questions about the motion of soccer balls. "How does ____ cause the ____ to ____? Why does ____ cause the ball/puck/marble to ____? If we do ____, how will the ball's/puck's/marble's motion change? What happens if we do ____?" (Lesson 2, Teacher Edition).
- Lesson 7, Synthesize section, Step 4: Students consider cause and effect questions when discussing the investigation results. "What caused the motion of the first ball to change before it collided with the second ball? What caused the motion of the second ball to change?" (Lesson 7, Teacher Edition).
- Lesson 8, synthesize section, Step 3: "What is causing the ball to slow down (and stop)? (Where does the energy go?) Since the ball is transferring energy to the sticky notes when it hits each of them, it has less energy to keep moving itself. When the ball has transferred all of its energy to moving the sticky notes, it does not have any more energy left to keep moving, so it stops" (Lesson 8, Teacher Edition).

EM: Energy and Matter

Claimed Element: EM: 4E3 Energy can be transferred in various ways and between objects.
Claimed in Lessons 5, 7, 8, 9, 10, 11, and 12. Evidence was found in 5, 7, 8, 9, 10, 11, and 12, examples include:

- Lesson 7, Synthesize section, Step 4: "How can we tell how much energy something has? The further it goes, the more energy it has. The faster it goes, the more energy it has. The slower it goes, the less energy it has" (Lesson 7, Teacher Edition).
- Lesson 8, Synthesize section, Step 3: "What is causing the sticky notes to move? (Where does the energy come from?) The ball is transferring energy to the sticky notes to make them move/ change shape when it contacts them or collides with them" (Lesson 8, Teacher Edition).
- Lesson 9, Navigate section, Step 1: "What is the evidence that energy is transferred to and from an object? We can see a change in shape. The object slows down or speeds up. When the ball slows down as it moves on the surface, this is evidence that energy transfers from the ball to the surface" (Lesson 9, Teacher Edition)

- Lesson 12, Synthesize section, Step 4: Students consider cause and effect when responding to questions on the final assessment. "How does the object get started moving?" (Lesson 12 Handout, Collisions: Written Explanation)

PAT: Patterns

Claimed Element: PAT: 4E2 Patterns of change can be used to make predictions
Claimed in Lesson 10. Evidence was found in Lesson 10.

- Lesson 10, Navigate section, Step 1: "Review the question with students and then use the prompts on the slide to make predictions about how and why sounds are produced in a collision. Give students 1-2 minutes to discuss with a partner before having them share their ideas with the class. Encourage students to use the "If…then…because…" sentence frame they have used in other investigations to make predictions. Jot down their predictions on a whiteboard, chart paper, or digital space for students to refer to throughout the lesson" (Lesson 10, Teacher Edition).

Claimed Element: PAT: 4E3 Patterns can be used as evidence to support an explanation.
Claimed in Lessons 5, 7, 10, 11. Evidence was found in lessons 5, 7, 10, and 11.

- Lesson 7, Synthesize section, Step 4: "Discuss the patterns we observe in our class graphs. Facilitate a class discussion about the patterns students notice in their class line plots" (Lesson 7, Teacher Edition).
- Lesson 10, Explore section, Step 2: "What patterns do you notice? The harder the stomp, the louder the sound. The softer the stomp, the quieter the sound" (Lesson 10, Teacher Edition).

Criterion-Based Suggestions for Improvement: NA

I.C. Integrating the Three Dimensions — Extensive

Student sense-making of phenomena and/or designing of solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs.

The reviewers found extensive evidence that grade-appropriate elements of the three dimensions are used together throughout the unit, and this integration is in service of figuring out the phenomenon of changes in motion of a kicked ball.

Throughout the unit, students engage in three-dimensional tasks to help explain phenomena.

- Lesson 3: "Make observations to serve as evidence for an explanation of the effects of the contact force present when objects collide" (Lesson 3, Teacher Edition)
    - Lesson 3, Synthesize, Step 3: The class considers several questions to explain their observations."What is the effect of the force (interaction) on the foot? What is the effect of that force (interaction) on the ball? What causes the ball to start moving in the first place? Would we observe a shape change if we could zoom in on a hockey puck? marbles?" (Lesson 3, Teacher Edition).

- Lesson 4: "Plan an investigation considering fair tests and controlled variables to produce data using a system whose components collide and cause changes in motion." (Lesson 4, Teacher Edition)
    - Lesson 4, Synthesize section, Step 4: "Prompt students to consider where we started. Invite students to consider the question that we were wondering about at the beginning of this lesson and how it led us to where we currently are: we were wondering how to test what keeps the ball moving on its own, but we can not always go outside or in the gym to kick the ball around. We figured out that we needed a way to carry out a fair test. We have a "Kick Investigation System" for us to use, but we need to decide how to use it in a fair way. Review with students how their physical kick system model is like an actual foot and ball" (Lesson 4, Teacher Edition).
- Lesson 11: "Make predictions to address if energy transfer results in heat when objects collide."
    - Lesson 11, Explore section, Step 3: Students plan an investigation where they shake a container of beans and measure the temperature before and after shaking. "Make predictions of what we think will happen in our investigation. Display slide I. If students have not yet done so, have them jot down their investigation question on their Shake-It-Up Investigation handout. Explain that now that we have our question and know what variable we are changing and the variables that are staying the same, we should be able to predict what we think will happen" (Lesson 11, Teacher Edition).

The integration of the three dimensions allows students to make sense of the phenomenon over time.

- Lesson 9, Synthesize Section, Step 3, students integrate the use of the elements when they [write an explanation of "How and why does a marble's motion change?"] in the three dimensions: EM: 5.E3 Energy can be transferred in various ways and between objects., DCI PS3.C Relationship Between Energy and Forces: When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3, and SEP CEDS: 6.E2: Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
- Lesson 12, Synthesize Section, Step 3, students integrate the use of the elements when they [write their collisions explanation] in the three dimensions: EM: 5.E3 Energy can be transferred in various ways and between objects, DCI PS3.C Relationship Between Energy and Forces: When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3, and SEP CEDS: 6.E2: Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.

Suggestions for Improvement: NA

I.D. Unit Coherence	Extensive

Lessons fit together to target a set of performance expectations.

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

The reviewers found extensive evidence that the lessons fit together coherently to target a set of performance expectations 4-PS3-1 and 4-PS3-3. Each lesson builds student understanding of the science ideas, practices, and Crosscutting Concepts needed to explain the phenomenon of how the motion of a kicked ball changes.

i. 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.

- Open Sci Ed Elementary Teacher Handbook, Navigate Component, "The Navigate component directly supports coherence for students from lesson to lesson. This component generally happens at the beginning and end of each lesson and provides opportunities for the class to take stock of where they are in finding answers to their questions, remind themselves what they figured out last time, and decide where they want to go next. Often this navigation will come naturally from questions generated by students, but occasionally the teacher will "problematize" an idea or investigation result by asking a salient question or pushing the class to consider other situations or new directions." (Open Sci Ed Elementary Teacher Handbook)
- Lesson 2, Synthesize section, Step 4: Students share and organize their questions on a Driving Question Board (DQB). "Build our Driving Question Board. Display slide P. Explain that it is important that we hear everybody's questions, and we might find that we have questions similar to some of our classmates' questions. As we share, we'll organize our questions into groups so we can more easily plan investigations and track what we have figured out" (Lesson 2, Teacher Edition).
- Lesson 3, Navigate section, Step 4, "Explain that we know that a force from the foot was needed to get the ball moving. The collision between the foot and the ball caused the ball to move. Wonder aloud something like, But what is happening after that, when the ball keeps moving? Problematize that the foot is not in contact with the ball the whole time it is moving--the foot does not continue to push the ball, so what is making the ball keep moving? (Leave this question hanging for next time.)" (Lesson 3, Teacher Edition)
- Lesson 6, Navigate section, Step 1, "Remind students that we left our investigation last time wondering about how a kick is like other collisions. Tell students that scientists often reuse materials they already have to answer new questions. Ask students how we could reuse our Kick Investigation System to test how a kick is like other collisions.." (Lesson 6, Teacher Edition)
- Lesson 7, Navigate section, Step 5, "Suggest to students that as a class we have been focused on how a ball starts moving and how it moves, and in this lesson, we started to figure out some ideas about why the ball slows down or speeds up. Direct students to the Driving Question Board and have them review questions related to rolling, why a ball slows down, or why a ball stops. Emphasize questions related to surfaces and how they affect a ball's motion." (Lesson 7, Teacher Edition)

ii. The lessons help students develop toward proficiency in a targeted set of performance expectations.
The unit targets two Performance Expectations.

- 4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object.
- 4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide. (Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.)

Suggestions for Improvement: NA

I.E. Multiple Science Domains — Extensive

When appropriate, links are made across the science domains of life science, physical science, and Earth and space science.

i. Disciplinary core ideas from different disciplines are used together to explain phenomena.
ii. The usefulness of crosscutting concepts to make sense of phenomena or design solutions to problems across science domains is highlighted.

The reviewers found extensive evidence that the phenomenon can be explained using only science ideas from the physical science (PS) domain. The phenomenon involves explaining how the motion of a kicked ball changes and uses science ideas from PS3.A— Definitions of Energy, PS3.B—Conservation of Energy and Energy Transfer, and PS3.C—Relationship Between Energy and Forces.

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

- PS3.A Definitions of Energy
  - The faster a given object is moving, the more energy it possesses.
  - Energy can be moved from place to place by moving objects or through sound, ~~light, or electric currents~~.
- These DCIs are built through the unit. "In Lessons 4 and 5, students investigate how more force (a "bigger" kick) transfers more energy to a ball, which then travels faster and farther before stopping. In Lessons 6 and 7, students explore how a kick is like other collisions by investigating what happens when we kick an object into a stationary object. They observe in this investigation that the harder a kick is, the farther the second ball travels, and the faster it moves. It moves faster because it has more energy. In Lesson 10, students explore sound from collisions, and gather evidence that energy can be transferred via sound to the surroundings and also cause changes in motion of objects" (Energy Transfer Collisions Unit Front Matter).
- PS3.B Conservation of Energy and Energy Transfer
  - Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
- This DCI is built through the unit. "In Lessons 1-9, students explore the changes in motion that occur following a collision. In Lessons 10 and 11, students expand their evidence of energy transfer to include observations of sound and heat. They leverage observations from prior lessons and recognize that in all their investigations, the objects that were in motion eventually slowed down and stopped, whether or not they collided with other objects. This discussion and an investigation of a kick pedal drum motivates students to wonder where the energy is going that causes a ball to slow down. They identify sound and heat as additional evidence of energy transfer in collisions between objects and with a surface" (Energy Transfer Collisions Unit Front Matter).
- PS3.C Relationship Between Energy and Forces
  - When objects collide, the contact forces transfer energy so as to change the objects' motions.
- This DCI is built through the unit. "In Lessons 1-9, students explore the changes in motion that occur following a collision. Through asking testable questions, planning and carrying out fair test investigations using a designed kick investigation system, and constructing explanations using evidence generated from fair test investigations, students figure out that changes in motion such as speeding up or slowing down, changing from moving to not moving, and/or from not moving to moving, are all evidence that energy

transfer has happened. Students also gather evidence that changes in shape are also evidence of energy transfer. They identify that energy is transferred through contact forces objects experience in a collision. In Lesson 9, they apply their ideas and the evidence they gathered to explain how energy is transferred from one marble to another (a game they experienced in Lesson 2)" (Energy Transfer Collisions Unit Front Matter).

The phenomenon can be fully addressed within the physical science domain. The essential science concepts are described in the document "About the Science".

- "This unit supports students in developing foundational ideas about energy, its relationship to changes in motion and shape, and evidence we can observe that tells us an energy transfer has occurred between two colliding objects" (About the Science).
- "The lessons in this unit focus on developing an understanding of energy and energy transfer through collisions. You will support students in developing the idea that contact forces between two colliding objects (e.g., foot and soccer ball) transfer energy from one object to the other" (About the Science).

Suggestions for Improvement: NA

I.F. Math and ELA — Extensive

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.

The reviewers found extensive evidence that the materials provide grade-appropriate connections to the Common Core State Standards (CCSS) in Mathematics and English Language Arts. The materials include side callouts when important CCSS are used in the lessons and information for the teacher on how the CCSS connections are developed.

Energy Transfer Collisions Unit Front Matter, "Several of the ELA Common Core State Standards for 4th are addressed regularly in many lessons of a unit because they are intertwined with students' science learning and their communication of their sensemaking. The table below describes the ELA Common Core State Standards that are practiced regularly in lessons but that do not always have explicit callouts in a lesson. This is because these standards, or key parts of these standards, are addressed so frequently that it would be repetitive to keep calling them out within the Teacher Guide. They are listed and explained here, and they are also listed on the Unit Connections to the Common Core Standards matrix with a checkmark (✓)." (Teacher Edition)

The following standards are explicitly used and named in the lesson with specific support for teachers:
CCSS-ELA-LITERACY.L.4.2D Spell grade-appropriate words correctly, consulting references as needed.
Claimed as supported in Lessons 9. Evidence was found in Lesson 9. Examples include:

- Lesson 9, Synthesize Section, Step 3, sidebar, Literacy Supports, "As students write their explanations, encourage them to remember to use the word wall to spell words correctly, or to use other references available in the classroom, such as dictionaries or glossaries. This supports students in making progress towards L.4.2D, which states that students are able to spell grade-appropriate words correctly, consulting references as needed." (Lesson 9, Teacher Guide)

CCSS-ELA-LITERACY.L.4.4B Use common, grade-appropriate Greek and Latin affixes and roots as clues to the meaning of a word (e.g., telegraph, photograph, autograph).
Claimed as supported in Lessons 6. Evidence was found in Lesson 6. Examples include:

- Lesson 6, Synthesize Section, Step 4, sidebar, Literacy Support, "Determine the meaning of "prediction" using what students know about the root word "predict." Students should then be able to determine the meaning of other related word forms like prediction" and "predictable." Knowledge of these word forms supports students' sensemaking. This practice also helps students learn how to apply common root words as clues to the meaning of a word and supports CCSS-ELA-LITERACY.L.4.4B."

CCSS.ELA-LITERACY.RI.4.2 Determine the main idea of a text and explain how it is supported by key details; summarize the text.
Claimed as supported in Lessons 4 and 11. Evidence was found in Lessons 4 and 11. Examples include:

- Lesson 11, Connect Section, Step 5, "As you read aloud, and prompt students with questions, ask students to summarize what they read on the page and to use details in the book to support their thinking. Determining the main idea of a text and explaining how it is supported by key details supports CCSS-ELA-LITERACY.RI.4.2 as students read and summarize an informational text." (Lesson 11, Teacher Edition)

CCSS-ELA-LITERACY.RI.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.
Claimed as supported in Lessons 8. Evidence was found in Lesson 8. Examples include:

- Lesson 8, Connect Section, Step 5, "As students compare and contrast articles, they are gaining a greater understanding of the role that surfaces play in sports. In fourth grade, students should be able to synthesize information from texts to make a bigger claim about the phenomenon they are learning about. This supports students' progress toward CCSS-ELA-LITERACY.RI.4.9 and being able to integrate information from texts on the same topic to write or speak about the subject knowledgeably." (Lesson 8, Teacher Edition)

CCSS-ELA-LITERACY.SL.4.1B Follow agreed-upon rules for discussions and carry out assigned roles.
Claimed as supported in Lessons 3. Evidence was found in Lesson 3. Examples include:

- Lesson 3, Explore Section, Step 2, "Prompt students to write or speak using present progressive verbs (e.g., was kicking, am kicking, will be kicking) when describing events that happened, such as when they are sharing observations they made during an investigation. Giving students an opportunity to practice using conventions of standard English and using a variety of sentence structures supports them in working toward CCSS-ELA-LITERACY.L.4.1B." (Lesson 3, Teacher Edition)

CCSS-ELA-LITERACY.SL.4.2 Paraphrase portions of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.
Claimed as supported in Lessons 10. Evidence was found in Lesson 10. Examples include:

- Lesson 10, Connect Section, Step 4, "Asking students to paraphrase or summarize information from text helps students to monitor their comprehension of conversations and texts to support their sensemaking. Supporting students to paraphrase portions of a text or different oral and visual media helps students make progress toward CCSS-ELA.LITERACY.SL.4.2." (Lesson 10, Teacher Edition)

CCSS-ELA-LITERACY.SL.4.3 Identify the reasons and evidence a speaker provides to support particular points.
Claimed as supported in Lessons 5. Evidence was found in Lesson 5. Examples include:

- Lesson 5, Synthesize Section, Step 6, "As you facilitate this student-student discussion, encourage students to identify evidence a peer provided to support a particular point they made. The evidence could come

from their data tables, line plots, or even their Class Consensus Model. Giving students an opportunity to practice CCSS-ELA-LITERACY.SL.4.3 helps students identify evidence that a speaker uses to support their thinking while also providing opportunities for using evidence to support sensemaking." (Lesson 5, Teacher Edition)

CCSS-ELA-LITERACY.W.4.2D Use precise language and domain-specific vocabulary to inform about or explain the topic.
Claimed as supported in Lessons 7 and 12. Evidence was found in Lesson 7. Examples include:

- Lesson 7, Synthesize Section, Step 4, "Encourage students to use force, collision, energy, and energy transfer in their responses to these questions as this conversation is intended to build towards a synthesis of what we figured out. Using precise vocabulary in written language provides a meaningful opportunity for using vocabulary words in appropriate contexts. Continue to encourage their use of these important words to support CCSS-ELA-LITERACY W.4.2D as students use precise language and vocabulary to inform about or explain a topic." (Lesson 7, Teacher Edition)
- Lesson 12: there is no explicit support for this standard in this lesson.

CCSS-ELA-LITERACY.W.4.4 Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
Claimed as supported in Lessons 1. Evidence was found in Lesson 1. Examples include:

- Lesson 1, Synthesize Section, Step 3, "Encourage students to refer back to their Notice and Wonder chart and add details to their model to explain what they noticed and to try to explain what they wondered. Also remind students that their classmates are their audience for this task--students will use their models to explain their thinking as the class identifies what we need to figure out in this unit. Considering the audience supports CCSS-ELA-LITERACY.W.4.4 as students develop and organize their writing so that it is appropriate to task, purpose, and audience." (Lesson 1, Teacher Edition)

Mathematics
Energy Transfer Collisions Unit Front Matter, "Mathematical practices (MP4, MP6, and MP7) along with crosscutting concepts are employed throughout the unit to develop student understanding of science ideas and deepen science practices. In this unit, students will use line plots to represent the measurements for the distance a ball travels and analyze and interpret patterns in the data (part of 4.MD.A.2) in lessons 5, 7, and 8. Students will continue to analyze and interpret data from tables and line plots for evidence of energy transfer in collisions in lessons 10 and 11." (Unit Front Matter)

Unit Connections to the Common Core Standards, "In the OpenSciEd Elementary program, students use mathematics to support them in making sense of their science work. We have noted in the table below the standards that are supported within lessons in this unit. You may find opportunities to expose students to more math standards than those we have noted in any given lesson, but we have provided this table as a starting point for your instructional planning. ∗ = This standard is explicitly used and named in the lesson with specific support for teachers."

CCSS-MATH-Practice.MP4 Model with mathematics.
Claimed as supported in Lessons 5, 7, and 8. Evidence was found in Lessons 5, 7, and 8. Examples include:

- Lesson 7, In Lesson 7, Explore Section, Step 2, "Students use a line plot to represent the measurements for the distance a ball travels and analyze and interpret patterns in the data (MP4 and part of 4.MD.A.2). Students' work with the line plots can be extended to display the measurements in fractions of a unit (i.e. 1/8, 1/4, and/or 1/2 meters) to support part of 4.MD.B.4." (Lesson 7, Teacher Edition)

CCSS-MATH-Practice.MP6 Attend to precision.
Claimed as supported in Lessons 5, 10, and 11. Evidence was found in Lessons 5, 10, and 11. Examples include:

- In Lesson 11, Explore Section, Step 3, "In this investigation, students keep track of time in minutes. Students should attend to the measurement of time precisely to help one another ensure there is enough time for collisions to occur so that a temperature change will be noticed. (MP6)" (Lesson 11, Teacher Edition)

CCSS-MATH-Practice.MP7 Look for and make use of structure.
Claimed as supported in Lessons 10. Evidence was found in Lesson 10. Examples include:

- In Lesson 10, Explore Section, Step 2, "Students analyze and interpret patterns in the line plots representing the measurements for sound (in decibels) for different kick sizes (MP7). Support students in noticing that the scale for the line plots begins at 65 and not 0 like the other line plots in this unit (MP6)." (Lesson 10, Teacher Edition)

CCSS-MATH-4.MD.A.2 Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.

- Lesson 5, Connect section, Step 2: "Have students use a line plot to represent the measurement of the distance the ball travels for each kick size" (Lesson 5, Teacher Edition).
- Lesson 7, Explore section, Step 3: "Students use a line plot to represent the measurements for the distance a ball travels and analyze and interpret patterns in the data" (Lesson 7, Teacher Edition).
- Lesson 8, Explore Section, Step 2: "Similar to Lesson 7, students represent the measurements for the distance a ball travels with a line plot and analyze and interpret patterns in the data" (Lesson 8, Teacher Edition).

Suggestions for Improvement: NA

CATEGORY II
NGSS Instructional Supports

II.A. Relevance and Authenticity — Extensive

Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world.

i. Students experience phenomena or design problems as directly as possible (firsthand or through media representations).
ii. Includes suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate.
iii. 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.

The reviewers found extensive evidence that the materials engage students in authentic and meaningful scenarios through multiple experiences with the phenomenon and connections to students' own lives and experiences. Students experience the phenomenon as firsthand as possible while making connections to their own lives and communities. The unit is anchored by the phenomenon of what causes the motion of a kicked ball to change. The phenomenon is authentic to students when they view the video, then go outside and kick a soccer ball. The unit guides teachers on how to use student experiences to help students understand and explain the phenomenon.

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

Students experience the phenomenon through a variety of videos and student exploration.

- Lesson 1, Connect Section, Step 2: "Follow these directions to start exploring how a soccer ball moves: Kick a soccer ball back and forth between you and a classmate or two. Be sure to keep the ball on the floor or ground when you kick it. Each time you kick, back up so you put more distance between you and your classmate(s). Even as you get farther away, keep the ball on the ground when you kick it. As you kick back and forth, observe what you see, what you hear, and what you feel about the soccer ball's motion (Lesson 1, Slides, Slide B).
- Lesson 1, Explore Section, Step 2, "Watch an optional video of soccer ball motion. If your class is not able to experience kicking or rolling soccer balls around either inside or outside the classroom, show the Kicking a Soccer Ball video (also embedded on slide D) as an alternative." (Lesson 1, Teacher Edition)
- Lesson 3, Explore section, Step 2, "Watch the video. Play the Slow Motion Soccer Kick video linked in slide C and give students about 30 seconds to jot down observations. If needed, watch the video a second time so that students can record additional observations." (Lesson 3, Teacher Edition)

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

- Lesson 1, Connect section, Step 4, "When you leave school today, look for and think about other situations where objects are moving like a soccer ball does. How is the object moving without a motor or muscles? What made it move and stop? What did you observe (see, hear, feel)? You might talk with other people in your family or community to gather some of their ideas, too." (Lesson 1, Slide L).
- Lesson 8, Connect section, Step 4, "Where are some places where people play soccer (or football)? Which soccer surface would you like to play on? Why?" (Lesson 8 Slides, Slide K)
- Lesson 10, Connect section, Step 3, "Turn and tell a partner: Have you observed (seen or felt) sound moving something? What made it move? How did it move?" (Lesson 10 Slides, Slide E)

iii. 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.

- Lesson 1, Connect section, Step 1: "Have an Initial Ideas Discussion as a whole class. After 3-5 minutes of partner talk time, invite a couple of students to briefly share about games they've played/seen with balls or pucks, such as where the game was being played (e.g., on the grass, inside a gym, on a table) how the ball or puck was moving (kicked and rolled, thrown and caught, hit and slid, bounced, pushed, etc.)." (Lesson 1, Teacher Edition)
- Lesson 1, Explore Section, Step 2, "Give instructions for going outside (or to the gym). Tell students we are going to go outside and observe what we see, hear, and feel when a soccer ball moves. We are making observations to build on the ideas we just discussed. Remind students that to observe means to notice details. Today, we will be observing what we can see, hear, and feel about how a soccer ball moves. Recall a few examples from the Connect about what students saw, heard, and felt. Facilitate a 1- to 2-minute discussion with students about previous experiences with a soccer ball and what they might see, hear, and feel when they go outside (or to the gym) to observe how a soccer ball moves." (Lesson 1, Teacher Guide) Students' prior experiences related to how soccer balls move when kicked help to create a need to investigate more about how a soccer ball moves.
- In Lesson 10, Connect section, Step 4: "Ask students to consider other sounds they have heard that are caused by collisions. As students share, consider jotting down their responses on their Related Phenomenon chart from lesson 1. Have students turn and tell a partner first, then share examples as a class." (Lesson 10, Teacher Edition, p11)

Suggestions for Improvement: NA

II.B. Student Ideas — Extensive

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.

The reviewers found extensive evidence that the materials provide students with opportunities to develop new understandings by clarifying their own ideas and comparing their ideas to their peers' ideas. Students express their thinking in a variety of ways and get feedback from their peers and the teacher.

Student ideas are clarified, justified, and built upon

- Lesson 1, Explore section, Broadening Access Section "Encourage students to share their thinking in a variety of ways and representations. Validate all the ways we communicate our ideas, such as with gestures or body movements, drawings, and words from any languages your students use." (Lesson 1, Teacher Edition)
- Lesson 3, Synthesize Section, Step 3, The My Growing Ideas chart is introduced to students. There are teacher prompts to support students in reflecting on ways they have kept track of their learning prior to this unit. Students are encouraged to think about the My Growing Ideas chart as a place they can use to keep track of their thinking over time. There is an example for teachers of what a student may include in this first posting. There is a Teacher Tip on the sidebar that explains the purpose of the My Growing Ideas

chart: "The My Growing Ideas chart will be used multiple times throughout this unit. This is a space for students to write and/or draw what they have figured out in a lesson, and to see how their thinking changes over time. It is not intended to be graded. See the Teacher Handbook for more information. Have students keep this chart easily accessible so they can see how their ideas develop throughout the unit. The next use of the My Growing Ideas chart will be in the final Navigate in Lesson 5." (Lesson 3, Teacher Guide)

- Lesson 7, Navigate Section, Step 5, "Update My Growing Ideas Chart. Display slide I. Provide each student with a copy of My Growing Ideas. Invite students to think about what we figured out about collisions through our investigation, and write down any questions they have about collision and energy transfer. Remind students this is their own space for jotting down their ideas and questions." (Lesson 7, Teacher Guide).
- Lesson 11, Synthesize Section, Step 6, "Update "My Growing Ideas" charts. Display slide O. Provide each student with a copy of My Growing Ideas. Invite students to write down what we figured out about collisions through our investigations of sound and heat and any questions they have about collision and energy transfer. Remind students this is their own space for jotting down ideas and questions." (Lesson 11, Teacher Guide)

Artifacts show evidence of students' reasoning and changes in their thinking over time.

- Lesson 6, Connect Section, Step 3, "Ask 2-3 students to share what feedback is and why it is important. Suggest a definition for feedback such as comments that help us to make improvements to our work. Then, have students turn and talk to discuss the prompts on the slide and then invite them to share their responses with the class. Distribute an Investigation Plan Feedback handout to each group. Ask students to review the handout together and to ask questions on anything they may be confused about. Then, give each student group an investigation plan written by another group. Try to ensure that groups are paired. For example, for groups A and B, Group A would review group B's plan, while Group B would review group A's plan. Have students read through the plan and then complete the Investigation Plan Feedback handout." & "Review feedback and revise the investigation plan. Display slide G. Have student groups swap their plans and feedback handouts, then give groups time to review the feedback they received and ask clarifying questions of one another. Then, give students time to revise their investigation plan. Collect peer review handouts to review student feedback according to the Following Student Sensemaking tool." (Lesson 6, Teacher Guide)
- Lesson 6, Lesson Assessment Guidance, the teacher is provided with ways to use key formative information from students that supports continued sensemaking, "Students are developing ideas about how to plan and carry out investigations to understand how the motion of objects changes following collisions. Broadening to include a moving object and a stationary object will be important for Lesson 7 when students solidify an understanding that the motion of all objects in a collision changes and that we can see evidence of energy transfer by observing changes in their speed. Use this assessment moment as an opportunity to see where your students are in their learning about planning investigations. The group planning (Explore) and peer review (Connect) serve as an additional scaffold before students plan other investigations later in the unit. Refer to the Following Student Sensemaking for examining students' developing understanding based on students' current sensemaking. The tool can be used as a guide for assessing either group or individual progress, depending upon your assessment needs, and can be used to assess Colliding Round Objects Investigation Plan and Investigation Plan Feedback." (Lesson 6, Teacher Guide)
- Lesson 8, Synthesize section, Step 4: "Directions: Think about the evidence we collected during our investigation. Use the lines and box below to write or draw and write your explanation that answers our lesson question. Use the patterns you observed and what we have learned about energy transfer and surfaces to help answer the question" (Lesson 8 Handout, Constructing Explanations).

- Lesson 9, Lesson Assessment Guidance, "Opportunities to revise explanations will provide students with additional support in making progress on their understanding of how to use evidence to construct explanations of energy and energy transfer between objects." (Lesson 9, Teacher Guide)Lesson 10, Synthesize section, Step 6: "Directions: Work with your group to complete the sentence starters to explain a sound you heard at school that was caused by two objects colliding. Then, identify evidence to support your explanation" (Lesson 10 Handout, Sound Explanation).

Students receive feedback and revise their thinking accordingly.

- Lesson 6, Connect section, step 3, "Review feedback and revise the investigation plan. Display slide G. Have student groups swap their plans and feedback handouts, then give groups time to review the feedback they received and ask clarifying questions of one another. Then, give students time to revise their investigation plan. Collect peer review handouts to review student feedback according to the Following Student Sensemaking tool." (Lesson 6, Teacher Edition)
- Lesson 9, Synthesize Section, Step 4, Assessment Opportunity, "Self-assessment: Students' use of Self-Assessment provides an opportunity for students to reflect on their progress concerning learning goals 9.A. and 9.B, to help them identify improvements they can make the next time they are asked to complete similar tasks. Consider using the self-assessment in combination with the Teacher Rubric for Marbles Explanation to provide feedback to students on the Model of Marbles Collisions." (Lesson 9, Teacher Guide)

Suggestions for Improvement: NA

II.C. Building Progressions — Extensive

Identifies and builds on students' prior learning in all three dimensions, including providing the following support to teachers:

i. Explicitly identifying prior student learning expected for all three dimensions
ii. Clearly explaining how the prior learning will be built upon.

The reviewers found extensive evidence that the materials identify and build upon students' prior learning in all three dimensions. Information is provided on what proficiencies students are expected to have from previous learning in all three dimensions. A plan for the progression of learning in targeted elements is described for teachers.

i. Explicitly identifying prior student learning expected for all three dimensions

Information about prior learning is found in the section of the Unit Overview called "What ideas and experiences will my students bring that can help them in this unit?" This information covers the three dimensions but does not provide information about learning in the specific elements of the dimension.

- Unit Overview: "Forces: In OpenSciEd Unit K.3: How can we move things to where we want them to go? (Mighty Movers Unit), students explore pushes and pulls, figuring out that strength, direction, and speed are qualitative descriptors of forces and motion. They also explore collisions, learning that collisions happen

when objects touch or collide, and they push on one another and can change motion" (Energy Transfer Collisions Front Matter). This information does not specify which DCI element is being addressed.

- Unit Overview: "Planning and carrying out investigations: Students will come into this unit having made observations and carried out many investigations in and out of school. Through these experiences they will have come to recognize that making observations includes using our senses (see, hear, feel, smell, and sometimes taste) to notice details. They will also likely come into this unit knowing that we plan and conduct investigations to produce data to serve as the basis for evidence, that we can make predictions of what we think will happen in an investigation, and that we can ask questions that can be answered by an investigation. In Balanced Art Unit students build on these foundational understandings and are introduced to procedures, changing only one variable at a time during an investigation, and continue to practice recording detailed observations and data from their investigations. All of students' experiences with planning and carrying out investigations are leveraged in this unit to plan and carry out fair tests that include multiple trials, to consider variables that stay the same and that change, and identify the evidence we gathered through analysis and interpretation of recorded data" (Energy Transfer Collisions Front Matter) This information does not specify which SEP element is being addressed.
- "Throughout K-2, students have developed ideas about cause-and-effect relationships arising from observable patterns. In *Balanced Art Unit* students use their ideas about cause-and-effect to design fair tests and write if/then statements to capture their observations. In this unit, students leverage these experiences with using a cause-and-effect lens to consider causes that affect systems (a kick system or kick investigation system), and what the potential effects might be (predictions). Whenever students are participating in Building Understandings Discussions or Consensus Discussions, cause-and-effect thinking is used to make sense of energy and energy transfer, particularly as students think about where the energy is coming from, where the energy is going, why it's being moved from place to place and what the effects of energy transfer are. The effects ultimately become our evidence that energy transfer has happened (e.g., changes in motion, changes in shape, hearing sound, and feeling heat). While this unit does not establish that one cause (e.g., a collision) can have multiple effects (motion changes, sound, and heat), students are building this foundational idea that will be elaborated on in middle school." This information does not specify which CCC element is being addressed.

ii. Clearly explaining how the prior learning will be built upon.

- The Alignment with the Three Dimensions of NGSS document includes support for teachers about how students engage in each lesson with each of the three dimensions and sometimes how these ideas will be revisited, revised, or built upon in later lessons at the element level. For example, "AQDP-E3, Lesson 2: Students create questions for their Driving Question Board about the motion of objects in various sports and games and then discuss the ways the questions can be investigated. This lesson works only toward asking questions that can be investigated. In later lessons, students will use cause-and-effect patterns they have observed in their investigations to predict reasonable outcomes to their questions." & "EM-E3, Lesson 5: Students name the "push that keeps going" or "oomph" that the kick gives the ball as "energy." We also introduce the questions, "Where does the energy come from?" and "Where does the energy go?" which will support students' thinking about energy transfer throughout this unit. At this point in the unit, we are only focused on energy being transferred as motion; we will investigate other ways energy can be transferred in Lesson Set 2. Matter is not discussed in this unit."

In some of the lessons, information is provided that shows how certain SEPs, DCIs, and CCCs are developed.

- Lesson 1, Explore Section, Step 2, sidebar, Cause and Effect: "In this unit, students learn about causes that affect systems (such as what happens when we kick a soccer ball) and to recognize patterns in causes that help us to make predictions. When developing the Notice and Wonder chart with students, use the

suggested prompts as a way to introduce cause-and-effect thinking that students can build on throughout the unit." Teacher prompts in the discussion explicitly use the words cause and effect, such as, "What caused the ball to start moving?" (Lesson 1, Teacher Guide)

- Lesson 1, Explore Section, Step 2, sidebar, Asking Questions and Defining Problems: "In this unit, students will develop an understanding of what a testable (scientific) question is and work toward asking their own testable questions and predicting reasonable outcomes. Fostering curiosity about changes in a soccer ball's motion and providing students opportunities to wonder aloud about questions they have establishes a foundation for building toward questions that can guide our unit investigations." Teacher guidance on what possible questions are testable to look and listen for, such as, "Why does a harder kick make a louder sound?" "Why does the ball sound different moving on different surfaces?" "Does it matter what kind of shoes I'm wearing for how the ball feels?" (Lesson 1, Teacher Guide)
- Lesson 6, Synthesize Section, Step 4, sidebar, Cause and Effect, "As students make predictions based on their testable question, emphasize cause-and-effect relationships. In our experiment, the cause is the variable that we change (the "if" part of our statement; kick size) and the effects are the patterns we see (the "then" part of our statement; changes in motion). Encourage students to include the cause and their predicted effects in their prediction."
- Lesson 6, Synthesize Section, Step 4, "Tell students we will use our experiences and ideas we have figured out to make predictions about how and why the motion of two colliding balls changes after a collision. Explain to students that good predictions will describe what we think we will observe and why. Scientists often think about cause-and-effect relationships when they make a prediction. Have students briefly turn and talk with a partner about the variable they are testing (a cause) and what they think its effect will be." (Lesson 6, Teacher Guide)
- Lesson 11, Explore Section, Step 3, sidebar, Patterns, "Recognizing that patterns we have observed in previous investigations can be used as evidence to support predictions or explanations is a component of making progress toward asking questions and predicting reasonable outcomes. As students write their predictions, provide support as needed, including reviewing with students the cause-and-effect relationships they have observed so far in this unit and how they could be related to what we are investigating today." (Lesson 11, Teacher Guide)

Suggestions for Improvement

- Consider adding element identifiers (e.g., AQDP: 4.E1) to the discussion of prior learning in the Unit Overview.

II.D. Scientific Accuracy — Extensive

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

The reviewers found extensive evidence that student learning, in all three dimensions, is scientifically accurate, and the materials use grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning. The "About the Science" document supports the teacher, as it discusses the important

science ideas of the unit, the boundaries of science ideas, and some scientific information to build teacher understanding.

A document called "About the Science" discusses the unit's important science ideas, the boundaries of science ideas, and some science informational resources to build teacher understanding.

- About the Science: This unit supports students in developing foundational ideas about energy, its relationship to changes in motion and shape, and evidence we can observe that tells us an energy transfer has occurred between two colliding objects. Energy is likely a word that students have regularly encountered, such as being told food gives them energy or told they have too much or too little energy during a day's activities." (About the Science).
- About the Science: "The lessons in this unit focus on developing an understanding of energy and energy transfer through collisions. You will support students in developing the idea that contact forces between two colliding objects (e.g., foot and soccer ball) transfer energy from one object to the other." (About the Science).
- About the Science: "When we discuss heat, we are using the word as both a noun and a verb. When we use it as a noun, we are only referring to it as a feeling of warmth and as evidence of energy transfer. When we use it as a verb, we are using it as a means to describe changes in temperature that we can measure and feel. For the latter, we are only using heat to describe something becoming warmer. We do not talk about what happens to the temperature of the object that transfers its energy. We also do not explain why the air temperature we measure increases due to collisions. At this grade level, we do not expect students to explain how air molecules move faster when they have more energy, thus increasing the air temperature." (About the Science)
- About the Science: Adult-level resources around the science concepts are provided. "Jeff Nordine and David Fortus (2017). Chapter 4 Core Idea PS3 Energy. In Duncan, Kracjik, and Rivet (Eds)., Disciplinary Core Ideas: Reshaping Teaching and Learning. Arlington, VA: NSTA Press. Bozeman Science. Next Generation Science Standards video collection. PS3.A: Definitions of Energy: http://www.bozemanscience.com/ngs-ps3a-definitions-of-energy PS3.B: Conservation of Energy and Energy Transfer: http://www.bozemanscience.com/ngs-ps3b-conservation-of-energy-and-energy-transfer PS3.C: Relationship between Energy and Forces: http://www.bozemanscience.com/ngs-ps3c-relationship-between-energy-and-forces" (About the Science)

Evidence that students are coming to an understanding of scientifically accurate science ideas occurs throughout the unit.

- Lesson 3, Synthesize Section, Step 3: "Remind students that we made observations to figure out how the ball starts moving in the first place. Then, facilitate a discussion with students about what caused the ball to move and what happens as a foot kicks a soccer ball (or a hand hits a beach ball)." (Lesson 3, Teacher Edition)
- Lesson 7, Synthesize section, Step 4, "Emphasize to students that the changes in motion they are describing are evidence of energy transfer. Then, ask students to consider where the energy came from, where the energy went, and how we can tell how much energy something has. To help guide students through this discussion, you can use the Kick Investigation System. Push for students to identify the evidence that supports their responses. Where did the energy come from to make the first ball move?" (Lesson 7, Teacher Edition)

Suggestions for Improvement: NA

II.E. Differentiated Instruction — Adequate

Provides guidance for teachers to support differentiated instruction by including:

i. Supportive ways to access instruction, including appropriate linguistic, visual, and kinesthetic engagement opportunities that are essential for effective science and engineering learning and particularly beneficial for multilingual learners and students with disabilities.
ii. Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations.
iii. 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.

The reviewers found adequate evidence for teachers to support differentiated instruction. The materials provide support for learners through opportunities to represent thinking through a variety of modalities. Strategies for addressing the specific needs of learners are presented in the unit, including general extra support for students struggling to meet the targeted expectations. However, the unit provides one optional extension for students with high interest at the end of the unit and does not include support for students who have already met the performance expectations.

Provides guidance for teachers to support differentiated instruction by including:

i. Supportive ways to access instruction, including appropriate linguistic, visual, and kinesthetic engagement opportunities are essential for effective science and engineering learning and particularly beneficial for multilingual learners and students with disabilities.

- In the Elementary Teacher Handbook, "OpenSciEd units are also designed with differentiation in mind, allowing teachers to adapt the materials as necessary without diminishing the learning experiences for students. Teachers can find differentiation guidance within the Learning Plans in these types of callouts: **Broadening Access** callouts focus on moments in instruction in which a certain population may benefit from a particular strategy, for example, supporting language development for emergent multilingual learners, providing extended learning opportunities or readings for students with high interest, providing specific strategies for students with special learning needs. **Teacher Tip** callouts provide more specific instructions to teachers about how to make a learning activity successful based on their students' needs. The callout boxes provide a variety of instructions to modify the timing, grouping, or resources for a particular activity." (Elementary Teacher Handbook). All groups of learners are not necessarily supported in every activity, but they are usually supported when an obvious need arises. Some differentiation strategies explicitly clarify how they address the needs of all of the groups of students.
- In the Elementary Teacher Handbook, "OpenSciEd teacher materials also include educative features that are focused on multilingual students, such as callout boxes on the margins of the teacher guides. These educative features support teachers in considering whether particular learning moments might be spaces where they can leverage their multilingual students' language-related assets and/or address potential challenges their students might encounter. These educative features also help teachers provide additional in-time support and explain why these instructional moves are important for multilingual students." (Elementary Teacher Handbook)
- In OpenSciEd Elementary and Accessibility, Accessible Learning Strategies, "Multiple Ways to Communicate Learning. In elementary school, students have varied ways in which they might communicate their ideas. Often reading longer passages or writing are more challenging at this age, and often students

cannot fully express what they are thinking about their science ideas in written words alone. While OpenSciEd Elementary provides space in every lesson for students to practice writing, it is important to allow space for students to verbally describe their learning, to use hand gestures, and/or draw pictures. These are all valid and important ways for students to communicate their learning in science. We encourage you, the teacher, to integrate multiple forms of communication within each lesson investigation and at key assessment moments so that you can get a complete picture of what ideas your students are developing. You might also encourage students to use a combination of communication methods as well - such as writing one answer and then drawing or using hand gestures for another part of the handout. This allows for students to practice multiple means of communicating their learning during a lesson." (OpenSciEd Elementary and Accessibility)

- Lesson 1, Connect Section, Step 1, sidebar, Broadening Access, "This Initial Ideas Discussion provides an authentic opportunity for you to enhance students' language learning and language use for sensemaking work. You might find it helpful to use the Discussion Type Prompts teacher reference during the discussion. This handout provides teacher prompts that you could use to elicit and elevate students' ideas around the changing motion of objects." (Lesson 1, Teacher Guide)
    - Teacher Reference, Discussion Type Prompts. This handout has many discussion prompts broken into three categories: Initial Ideas Discussion, Building Understandings Discussion, and Consensus Discussion. Prompts for Initial Ideas include, "What are your ideas to explain/solve ____?Why/ how do you think ____ happens? How might we solve ____ problem? Have you ever experienced something like this? How was that like this?"
- Lesson 1, Connect Section, Step 1, sidebar, Broadening Access, "For students with a disability related to mobility, adjust this exploration for equitable participation. Work with a student's case manager as needed, but ideas for providing multiple means of engagement include using a hand to "kick" or move the ball, using a hockey stick to push the ball, or rolling the ball down a ramp to "kick" it to a partner." (Lesson 1, Teacher Guide)
- Lesson 1, Connect Section, Step 1, sidebar, Broadening Access, "Encourage students to share their thinking in a variety of ways and representations. Validate all the ways we communicate our ideas, such as with gestures or body movements, drawings, and words from any languages your students use." (Lesson 1, Teacher Guide)
- Lesson 1, Synthesize Section, Step 3, sidebar, Broadening Access, "Facing one another supports students' engagement and sense of shared mission. The Scientists Circle arrangement also allows students to orient to their peers and the ways their peers communicate ideas (e.g., using gestures, pointing to a map, talking across different languages). Share with students that professional scientists collaborate with one another to brainstorm, discuss, and review their work." (Lesson 1, Teacher Guide)
- In Lesson 4, Connect Section, Step 4, "Read Scientists Plan Investigations book and discuss these prompts." (Lesson 4, Teacher Edition) Specific differentiation strategies are not provided for multilingual learners to fully engage in reading the text and answering the teacher-prompted questions.
- Lesson 4, Explore Section, Step 2, sidebar, Broadening Access, "All students working in groups need opportunities to work with the activity materials. For example, all students need opportunities to manipulate the Kick Investigation System and to make a ball move. Supporting all students engaging in science classroom experiences is important for developing science identities, and is especially critical for those from non-dominant groups (girls, minoritized students of color) that have been historically excluded from science." (Lesson 4, Teacher Guide)
- Lesson 7, Synthesize Section, Step 4, sidebar, Broadening Access, "If you find that students need additional support to share their ideas with the class during a scientists' circle, consider having them share what they heard another student share in a small group or have another student share their idea for them so their voice is also heard. Be sure to remind students that if they share someone else's idea they give them

credit for it. An example sentence frame is "In my group, I heard …. say ….. and I agreed with that idea because…." (Lesson 7, Teacher Guide)

- Lesson 7, Synthesize Section, Step 4, sidebar, Broadening Access, "If time and resources allow, you might have your students record a video of themselves explaining what happened during the collision as an alternative or supplement to writing and/or drawing about it." (Lesson 7, Teacher Guide)
- Lesson 9, Synthesize Section, Step 2, sidebar, Broadening Access, "When you create the Gotta-Have-It Checklist, capture the rich ways your students express their ideas. This is especially important for multilingual students because their language resources and practices are not always noticed or valued in school spaces. If a student shares an idea using words or phrases in a named language other than English (e.g., in Spanish, Arabic, Mandarin, etc.), record their idea exactly as they shared it and then add a translation in English next to it. If possible, have students record ideas onto the chart themselves. Consider also writing examples of descriptions of changes in motion, the relationship between forces and energy, and evidence of energy transfer onto the chart." (Lesson 9, Teacher Guide)
- Lesson 11, Explore Section, Step 2, sidebar, Broadening Access, "Provide multiple means of representation. For student observations, tape a piece of paper to represent "before the collision" next to their observations (one that has no evidence of a collision). Tape a second one to represent "after the collision" (one that has a burned hole). This will allow the students to have a visual, alongside the text, of what was observed." (Lesson 11, Teacher Guide)
- Lesson 11, Synthesize Section, Step 6, sidebar, Teaching Tip, "If students need additional support to understand that heat and sound are also present when objects rub against each other, such as a ball rolling on the ground, have students rub their hands together. What do they feel? What do they hear?" (Lesson 11, Teacher Guide)

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

Evidence from the materials where the criterion was met,

- Lesson 3, Lesson Assessment Guidance, "Use the information you gather in two ways: (1) to guide follow-up questions during the discussion in the Synthesize and as the class works to revise the Class Consensus Model, and/or (2) to reinforce 3rd grade concepts. If you notice that students need additional support in understanding that a force is a push or a pull and/or that unbalanced contact forces are involved when the foot/hand and the ball come together, consider using the extension activity provided in the Extension Activity teacher reference. The extension opportunity reinforces 3rd-grade concepts that help build toward the idea that contact forces, such as collisions, transfer energy from one object to the other and result in a change in motion and shape. Students will figure out the role energy plays in Lesson 5." (Lesson 3, Teacher Guide)
- Lesson 3, Teacher Reference, Extension Activity, "The goal of this extension activity is to have students see and discuss multiple images and multiple ideas. Each image may be accurately described with multiple words from the word bank; as you circulate during the activity, encourage students to explain their thinking about why the word they chose describes the image. You may choose to label some of the images with the words from the word bank and display them on your Word Wall, especially if there were some your students were unsure about or if you know that students did not develop the ideas in 3rd grade."
- Lesson 7, Lesson Assessment Guidance, "To further support students in their understanding emphasize the questions: where is the energy coming from? Where is the energy going? Use the following prompts to support students in making cause-and-effect connections: What is the cause of the second ball moving? What is the effect of the collision between the two balls? Create with students an "evidence chart" based on what they gathered in their investigations that they can use in their explanations. (Lesson 7 Teacher Edition)

- Lesson 7, Lesson Assessment Guidance: "As you observe students working individually and collaboratively to carry out their plans, consider using the following scaffolds to support students: Say something like, "Writing down data is important. You're thinking about ways you can remember data and share it with others. How might we also organize our data so we can look at it all at once to notice patterns?" You may choose to further support students in two different ways: -using the book from lessons 4 and 5 to review the ways that scientists collect and organize data. -asking students to review their lesson 5 investigation data" (Lesson 7, Teacher Edition)
- Lesson 8, Materials Section, "Students will read one of each reading in pairs. If you have not already set up reading partners in your classroom, consider planning ahead for which students you will pair together to read this text. One strategy for creating reading partners is to think about your class in terms of reading fluency and pair highly-fluent readers with partners of "medium" fluency, and also pair less-fluent readers with partners of "medium" fluency. In this way, partners can support each other without (hopefully) getting frustrated." (Lesson 8, Teacher Guide) Consider sharing the reading level of each of the articles so that teachers can differentiate between the different reading fluencies.
- Lesson 10, Explore section, Step 3: 'If students need additional support in making a connection between the sound and the moving sprinkles, pause and have students draw their thoughts. You may use prompts like "where is the energy coming from in this video, where is energy going next (what's moving?)." Remind students that they have learned to use arrows to show the direction that energy travels. Encourage students to use an arrow to show energy transferring as sound" (Lesson 10, Teacher Edition).

iii. 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.

- Suggestions are not provided for adaptations if students begin the unit with significantly higher levels of prior proficiency than expected for the grade level in any of the three dimensions.
- Lesson 12, Synthesize Section, Step 4, sidebar, Teaching Tip, "Extension Opportunity: Consider providing the following opportunities to students to extend their learning from this unit: If students want to test their predictions they wrote in their assessments by collecting additional data, suggest using the Kick Investigation System they have used throughout the unit and adapt it for their investigation. Give them as much freedom as possible to decide the variables they want to manipulate and measure, and the materials they might need. Encourage students to pursue one of the remaining ideas for investigation that the class recorded in the Ideas for Investigation poster in Lesson 2. The same can be done to answer remaining questions on their Driving Question Board." (Lesson 12, Teacher Guide) This optional activity occurs at the end of the unit and does not address students who have already met the performance expectations.

Suggestions for Improvement

- In Lesson 8, consider sharing the reading level of each of the articles so teachers can differentiate among the different reading fluencies.
- Consider adding pathways for students who have demonstrated prior proficiency in the performance expectations and additional extensions before the end of the unit for students with high interest.

II.F. Teacher Support for Unit Coherence — Extensive

Supports teachers in facilitating coherent student learning experiences over time by:

i. 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.).

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

The reviewers found extensive evidence of teacher support for unit coherence. The materials support teachers in facilitating coherent learning experiences over time by providing strategies to link student learning from one lesson to the next.

i. 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.).

Navigation across lessons includes guidance and support for recognizing what students figure out in a lesson, what questions are left unanswered, and what new questions could be answered in the next investigation. Navigation routines make connections between lessons explicit to students.

The K-5 Teacher handbook relates information about the navigation routine used in the unit.

- K-5 Teacher Handbook: "**What is the instructional purpose of this component?** The Navigate component directly supports coherence for students from lesson to lesson. This component generally happens at the beginning and end of each lesson and provides opportunities for the class to take stock of where they are in finding answers to their questions, remind themselves what they figured out last time, and decide where they want to go next. Often this navigation will come naturally from questions generated by students, but occasionally the teacher will "problematize" an idea or investigation result by asking a salient question or pushing the class to consider other situations or new directions. **What are the potential outcomes of this component?** During the Navigate component, students ask questions, define problems, and make predictions. The class builds their sense of shared purpose, sees progress toward answering their questions, and takes ownership of their science work. (Teacher Handbook)

Throughout the unit, teacher guidance and strategies are provided to ensure that students see their learning in all three dimensions as coherently linked to the progress they make toward explaining the phenomenon of changes in motion of a kicked ball.

- Lesson 3, Navigate section, step 1, "Navigate into today's work. Display Slide A. Open today's work by recalling what students explored last time." In the sidebar, "When navigating into and out of lessons, provide multiple means of engagement by connecting to the student-generated Driving Question Board and the Ideas for Investigation chart. This helps to recruit interest because pointing out questions or groups of questions, and/or ideas for investigation that students generated, helps them to value the investigation they are doing in each lesson." (Lesson 3, Teacher Edition)
- Lesson 3, Navigate section, Step 7, "Motivate investigating what happens after the kick. Display slide L. Explain that we know there was a collision between the foot and the ball and a force caused the ball to move. Wonder aloud, "But what is happening after that, when the ball keeps moving?" Problematize the fact that the foot is not in contact with the ball the whole time it's moving - the foot does not continue to push the ball, so what is making the ball keep moving? (Leave this question hanging for next time.) If the

DQB includes questions such as these, point them out now to motivate the work we'll do next time. What would happen if you kicked the ball as far as you could? (would need to establish that farther does not equal better, just trying to see how to make that happen) If you kicked the ball really hard, would it keep going forever?" (Lesson 3, Teacher Edition, p18)

- Lesson 5, Navigate section, Step 6 "Prompt questions about energy transfer. Present slide J. Distribute the My Growing Ideas handout. Ask students to think about what we just figured out about energy transfer from our investigation. The soccer kick is one kind of collision. What questions do we have now, especially about other collisions and energy transfer? What happens with the first object? How do we know it gave its energy to the second object?" (Lesson 5, Teacher Edition)

Strategies that help teachers connect lessons are provided.

- In Lesson 3, Navigation section, Broadening Access: "When navigating into and out of lessons, provide multiple means of engagement by connecting to the student-generated Driving Question Board and the Ideas for Investigation chart. This helps to recruit interest because pointing out questions or groups of questions, and/or ideas for investigation that students generated, helps them to value the investigation they are doing in each lesson." (Lesson 3, Teacher Edition)
- In Lesson 7, Navigate section, Step 5: "Motivate investigations about surfaces. Suggest to students that as a class we have been focused on how a ball starts moving and how it moves, and in this lesson, we started to figure out some ideas about why the ball slows down or speeds up. Direct students to the Driving Question Board and have them review questions related to rolling, why a ball slows down, or why a ball stops. Emphasize questions related to surfaces and how they affect a ball's motion. Display slide J. Ask students what we could do to our kick investigation system to test how a surface affects a ball's motion. Accept all responses..." (Lesson 7, Teacher Edition)
- In Lesson 8, Synthesize section, step 3, in the sidebar, "At this point, we are explaining the interaction between the ball and the "pieces" of the grass or carpet because we can see those move or change shape and explain the energy transfer in terms of changes in motion. Students may propose ideas or questions about whether a similar energy transfer happens on harder surfaces like the sandpaper or tile. Welcome those questions and record them on the DQB - you can use them to help motivate investigations in the second lesson set." (Lesson 8, teacher edition)

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

Lesson side columns on the first page of every lesson showing where the last lesson ended and where the next lesson will go.

- Lesson 3:
  - "In the previous lesson, we identified related phenomena and explored the motion of hockey pucks and marbles. We generated questions to create our Driving Question Board and brainstormed Ideas for Investigation" (Lesson 3, Teacher Edition)
  - "In this Investigation Lesson, we watch a slow-motion video of a foot kicking a soccer ball and investigate what happens when a hand and a beach ball collide. We gather evidence that objects can change shape as a result of contact force, and we revise our Class Consensus Model to explain how the foot and the ball interact when the kick happens." (Lesson 3, Teacher Edition)
  - "In the next lesson, we will plan a fair test for investigating how a ball's motion changes based on the size of the kick. We will gather evidence from scientists about what is a fair test, and we will create an investigation plan." (Lesson 3, Teacher Edition)

Suggestions for Improvement: NA

II.G. Scaffolded Differentiation Over Time — Adequate

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.

The reviewers found adequate evidence that there is a change in the level of independence in the student use of the elements of the unit's focal SEPs: Asking Questions and Defining Problems, Planning and Carrying Out Investigations, Constructing Explanations, and Designing Solutions. Scaffolds are used in the early lessons, and those scaffolds are removed later in the unit for some of the SEP elements as students become more independent in the use of the SEP. Other SEP elements show little or no scaffolding because there are limited opportunities to use the element or because scaffolds are not removed as students work through the unit.

Each of the focal SEPs has a series of tasks where students are initially provided with scaffolds and then removed. As the unit progresses, students complete tasks with growing independence.

AQDP: Asking Questions and Defining Problems

AQDP 4.E1 Ask questions about what would happen if a variable is changed.

- In Lesson 8, Slide B, students answer the question, "What do you predict will happen when we change the variable of the surface the ball rolls on?" and then are prompted with the question, "What questions do you have about what might happen?" (Lesson 8, Slide B) This element is only used once, so there are no opportunities for changes in the level of independence.

AQDP 4.E2 Identify scientific (testable) and non-scientific (non-testable) questions.
Although students have multiple places in the unit where testable questions are determined, many of these experiences involve the class deciding on the most appropriate question and all groups using the same question for their investigation.

- Lesson 4, Navigate section, Step 1: "Identify testable and non-testable questions on our DQB. Display slide E. Have student pairs review the questions they identified are related to what we are wondering about and determine if they are testable or not. Remind students that it is okay if they are not, because we might still be able to gather evidence from a nonfiction book or talk to scientists to answer them. Using the prompts on the slide, have students mark the questions they think are testable." (Lesson 4, Teacher Edition).
- Lesson 6, Explore section, Step 2: Students work in groups to develop an investigation plan, including identifying a testable question. (Lesson 6, Teacher Edition)
- Lesson 8, Navigate section, Step 1: "Develop a testable question to guide our investigation. Briefly read questions related to changing surfaces on our Driving Question Board, the testable questions we have investigated so far, and our Ideas for Investigation. As a class come up with a testable question that could guide our investigation today, something similar to "What happens to the motion of the ball if we change the surface?" (Lesson 8, Teacher Edition)
- Lesson 11, Explore section, Step 3: "Decide what our testable question will be for this investigation. Have students look at their DQB questions about heat, and the question frames on their Fair Test Investigation Infographic. Then, have students turn and talk with a partner. As a class, decide on a question that is similar to how and why does the temperature of an object change after a collision?" (Lesson 11, Teacher Edition)

AQDP 4.E3 Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.

- Lesson 2, Lesson Assessment Guidance, "Use this information to uncover students' initial ideas about the kinds of questions they can ask about changes in an object's motion. This is not an opportunity to take a grade or score. You will have a chance to further clarify and discuss questions as you organize the Driving Question Board (DQB) and support students in generating ideas for investigation. Encourage students to rewrite their questions to become more open-ended, particularly if their questions can best be answered with a "yes" or "no". Their questions could begin with a "How" or "Why" and/or follow the structure of the prompts provided on slide M. As the class progresses through the unit, students will continue to use the questions placed on the Driving Question Board as they build understanding of what a testable question is (Lesson 4) and continue to plan investigations of testable questions (Lessons 6, 8, 10, and 11). Look at the types of questions your students have asked with the purpose of determining the support that students may need in upcoming lessons as they work toward asking testable questions that can help them understand cause-and-effect relationships. In particular, look for ways students' questions can be rewritten to be testable and be ready to provide examples as they plan to carry out investigations in subsequent lessons." (Lesson 2, Teacher Guide) Support for the teachers in guiding the class in asking *how* and *why* questions do not link these kinds of questions to the CCC of cause and effect.
- Lesson 4, Navigate section, Step 1: "Define scientific questions. Display slide C. Explain to students that we are wondering how we can test what keeps a ball moving on its own, and to plan an investigation that tests something, scientists must think about if their questions are testable or scientific. For a question to be scientific or testable, scientists need to be able to answer it with evidence they have observed" (Lesson 4, Teacher Edition). The class discussion serves as an introduction to scientific questions.
- Lesson 9, Navigate Section, Step 5, "Emphasize that we noticed sounds when we kicked and stopped the ball. If there are questions on the DQB that have not been answered about sound, make connections to those questions. Pass out new sticky notes and give students 1-2 minutes to think on their own and then 1-2 minutes to write on their own. Then give students 3-5 minutes to share new questions and ideas with their group. Any question that the group agrees is still not answered can be added to Driving Question Boards. After adding new questions, focus students on the questions about sound and ask them if they can come up with a testable question that can help them figure out how sound is related to a kick/the motion of a ball. Come to a consensus that could we investigate something like: how and why are different sounds produced in a collision?" (Lesson 9, Teacher Guide) Students have the opportunity to think on their own before sharing their questions. The link of how and why questions to the CCC of cause and effect is not explicitly made to students.
- Lesson 11, Explore section, Step 3: "Decide what our testable question will be for this investigation. Have students look at their DQB questions about heat, and the question frames on their Fair Test Investigation Infographic. Then, have students turn and talk with a partner. As a class, decide on a question that is similar to how and why does the temperature of an object change after a collision?" (Lesson 10, Teacher Edition) Students have the chance to think on their own before sharing their questions with the class.

INV: Planning and Carrying Out Investigations

INV 4.E1 Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

- Lesson 4, Explore, Step 2: Student groups first carry out an investigation without a concrete plan and then discuss their results. "Reach consensus that if every group did something different then we could not trust the results of the investigation. Decide that as a class, we need to come up with clear steps for what to do in our investigation. We already have our materials, we just need to be more specific about what to do with

them. Suggest that it might be helpful to look at some examples of directions so that we can get some ideas about how we can be more specific so that everyone knows what to do" (Lesson 4, Teacher Edition). The class then plans an investigation with a focus on variables, what to measure, and how to record data.

- Lesson 5, Navigate Section, Step 1, the class discusses the investigation they decided they needed to carry out at the end of Lesson 4. The teacher used prompts such as, "What are we investigating today?; What is a fair test investigation?; Why is our investigation plan a fair test?; What data are we collecting to answer our testable question?" (Lesson 5, Teacher Guide)
- Lesson 6, Explore, Step 2: In this lesson, students work in small groups to develop an investigation plan. "Divide students into groups of 3-4 students. Pass out the Investigation Plan handout to each group. Give students time to collaborate in groups on their investigation plan handout. As students work, it may be helpful to make visible the How Can We Test How a Ball Moves After the Kick? chart from Lesson 4. When they are done, collect the plans to pass them to other groups for review in the next step" (Lesson 6, Teacher Edition).
- Lesson 9, Synthesize section, Step 3: Students analyze two investigation plans and determine which one represents an investigation with a fair test.
- Lesson 10, Explore Section, Step 2, "Explain that you have some data from the class that carried out the sound investigation. However, before we can trust this data to help us answer our lesson question, we need to determine whether the investigation is a fair test. Distribute Sound Investigation handout. Have students work in groups of 3-4 to the investigation plan on Sound Investigation handout (they do not need to look at the results or observations, yet) and to discuss the prompts on Slide D. It may be helpful to Display slide B. Review the question with students and then use the prompts on the slide to make predictions about how and why sounds are produced in a collision. Give students 1-2 minutes to discuss with a partner before having them share their ideas with the class. Encourage students to use the "If…then…because…" sentence frame they have used in other investigations to make predictions" (Lesson 10, Teacher Edition). Students are provided with a sentence structure to make a scientific prediction.
- Lesson 11, Explore Section, Step 3, "Make predictions of what we think will happen in our investigation. Display slide I. If students have not yet done so, have them jot down their investigation question on their Shake-It-Up Investigation handout. Explain that now that we have our question and know what variable we are changing and the variables that are staying the same, we should be able to predict what we think will happen. Suggest to students that they have observed several cause-and-effect relationships so far in our unit, like when we learned that a bigger force causes more energy to be transferred to the ball, and they should be able to use what they have observed in previous investigations to help them make a prediction that answers their testable question" (Lesson 11, Teacher Edition). Students write their own question and provide their own prediction for the investigation)

INV 4.E2 Evaluate appropriate methods and/or tools for collecting data or design a solution to a problem.

- In lesson 6, Connect section, Step 3: Students analyze an investigation plan. "Look at the variable that changes. Using what you know about fair tests, explain why or why not their variable to change is a good choice. In your explanation, be sure to explain how changing that variable will help us figure out how a kick is like other collisions. If you do not agree with their choice, explain what you think they should change and why it will help them to better answer what we are trying to figure out" (Lesson 6 Handout, Investigation Plan Feedback).
- In Lesson 10, Explore secretion, Step 2: Student groups evaluate an investigation plan by considering several questions. "Turn and talk with your group. Is the question testable? How do you know? Did the class follow clear procedures? Did the class have a good plan for displaying and analyzing their data? Is this investigation a fair test? Can we trust the results of this investigation? (Lesson 10 Slides, Slide D)

- Lesson 11, Explore section, Step 3: The class evaluates an investigation plan and considers several questions about the plan. "What variables stay the same? What variable is changing? What would happen if we changed two variables? How many trials are we doing? What is a trial for this investigation?
- Students evaluate investigation plans by answering questions about the methods used. The use of scaffolding questions continues throughout the unit.

INV 4.E3 Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

- Lesson 2, Explore section, Step 3: Students first talk with a partner about what they observed and then share their observations in a class discussion. The teacher records the ideas of the class on a chart.
- Lesson 3, Explore section, Step 2: The class watches a video, and students fill out an Observation Chart similar to the one completed by the teacher in lesson 2.
- The teacher first models filling out an observation chart, and then students complete an observation chart on their own.

INV 4.E4 Make predictions about what would happen if a variable changes.

- Lesson 6, Explore section, Step 2: Students are introduced to the idea that a fair test involves changing only one variable. "If we want to plan a fair test, what do we need to think about? We can only change one variable." (Lesson 6, Teacher Edition).
- Lesson 8, Navigate section, Step 1: "If we change the variable of the ground or surface, what would we need to do to be sure our investigation is still a fair test? We need to control other variables" (Lesson 8, Teacher Edition).
- Lesson 8, Explore section, Step 2: "What do you predict will happen when we change the variable of the surface the ball rolls on?" (Lesson 8, Teacher Edition).
- Students learn basic ideas about variables and then make a prediction about what would happen if the variable changes, but there is only one opportunity to use this element. In lesson 11, students write a prediction, but that prediction is not based on changes in the variable.

CEDS: Constructing Explanations and Designing Solutions

CEDS 4.E1 Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard)

- In Lesson 7, Explore Section, Step 3, "Construct an explanation based on our group data. Display slide D. Remind students that when we answer "how" we need to describe what we observed (the effect), and when we answer "why" we are describing what we think caused what we observed. Direct students to the sentence frames on the slide and discuss how the frames connect to answering "how and why" questions. Give groups time to practice using the sentence frames to respond to Question #5 on their handout." (Lesson 7, Teacher Edition)
- In Lesson 7, Synthesize Section, Step 4, "Construct an explanation. Display slide H. Have students revisit their response to question number 4 on Colliding Round Objects Line Plots. Invite students to think about what we figured out about collisions through our investigation and our discussion. Then, have students briefly turn and talk with a partner about how they would revise their explanation." (Lesson 7, Teacher Edition)
- In Lesson 7, Synthesize Section, Step 4, "Distribute Construct an explanation about energy during a collision and ask students to write in their own words, or draw what we now know about collisions and energy transfer." (Lesson 7, Teacher Edition)
- Within the lesson, students first use sentence frames, then talk with a partner and revise their explanations. Finally, students write their own explanations.

CEDS 4.E2 Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.

- Lesson 3, Synthesize section Step 3: The class has a discussion explaining the movement of a soccer ball.
- Lesson 5, Synthesize section, Step 6: "Construct an explanation to answer our investigation question. Display Slide K. Using the prompts on the slide, come to consensus with students on what we have figured out based on the evidence we collected in our fair test investigations. As they share their oral explanations, consider jotting them down on a whiteboard, chart, or digital space" (Lesson 5, Teacher Edition).
- Lesson 8, Synthesize, Step 4: After discussing with the class and creating a class consensus model, students individually completed a formative assessment, Constructing Explanations, in which they explained their understanding of the investigation question.
- Lesson 9, Synthesize section, Step 2: The class constructs a checklist of important items for an explanation, and then students individually explain marble collisions.
- Lesson 12, Synthesize, Step 3: "Individually construct explanations of an objects' motion changes. Distribute Model of Collisions or Comic Strip of Collisions or Written Explanation of Collisions to each student. Also, remind students that an important part of their model is to use evidence to support their ideas. To provide evidence students can look back at the list of evidence the class created" (Lesson 12, Teacher Edition)
- Students work together as a class; then, students work individually on explaining the movement of a ball. The summative assessment also involves students individually writing an explanation.

CEDS 4.E3 Identify the evidence that supports particular points in an explanation.

- Lesson 9, Navigate section, Step 1: The class discusses evidence from watching a ball move. "What is the evidence that energy is transferred to and from an object? We can see a change in shape. The object slows down or speeds up. When the ball slows down as it moves on the surface, this is evidence that energy transfers from the ball to the surface" (Lesson 9, Teacher Edition).
- In Lesson 9, Synthesize Section, Step 3, "Remind students that an important part of their explanation is to use evidence from the video, observations they made playing a game of marbles, or observations from their investigations to support their ideas. They should also use the class's Gotta-Have-It Checklist and Class Consensus Model to support their thinking for their explanation. If it's helpful, they can refer to their science notebooks and other class charts, too." (Lesson 9, Teacher Edition) Students work independently on this task.
- In Lesson 10, Synthesize Section, Step 6, "Work in small groups to explain a sound-producing collision. Display slide R. Remind students that we have been working to develop explanations supported by evidence, so let's work to explain one of the sound-producing collisions that we might have just mentioned, or that happen in our classroom, such as a dropped pencil or closing door." (Lesson 10, Teacher Edition)
- It is not clear that students understand how to use evidence to support an explanation before they are expected to write an explanation on their own.

Suggestions for Improvement

- In the Alignment With the Three Dimensions of *NGSS* document, consider including when the Constructing Explanations and Designing Solutions explanation is being created as a group rather than individually, to show how scaffolding is explicitly reduced over time.
- Consider using all claimed elements several times in the unit, with scaffolding reduced over time.

CATEGORY III
Monitoring NGSS Student Progress

III.A. Monitoring 3D Student Performance

III.B. Formative

III.C. Scoring Guidance

III.D. Unbiased Tasks/Items

III.E. Coherent Assessment System

III.F. Opportunity to Learn

III.A. Monitoring 3D Student Performance — Extensive

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.

The reviewers found extensive evidence that students have multiple opportunities to show what they have figured out about a phenomenon. The formative tasks provide many opportunities for students to show their understanding of the phenomenon. The summative tasks match the learning goals and use an understanding of the anchor phenomenon to explain connected scenarios. In both formative and summative tasks, students produce artifacts in which elements of all three dimensions are produced, showing proficiency in the targeted learning goals.

The formal tasks ask students to explain an interesting phenomenon using elements of the three dimensions cited as focal elements.

Evidence from the materials where the criterion was met.

- Lesson 9, Synthesize, Step 3: The class develops a list of important components of a model explaining the collisions of marbles, which is a new phenomenon. The assessment follows. "Individually create models of the marbles' motion changes. Present slide D. Distribute Model of Marbles Collisons and point out that in a game of marbles, there is not only one collision. Explain that the model page includes spaces to explain the marble's changing motion through two collisions" (Lesson 9, Teacher Edition). This assessment incorporates focal elements in the SEPs of Constructing Explanations and Planning and Carrying out Investigations, as well as the CCC element of Energy and Matter. In addition, two focal DCI elements are used.
- Lesson 12, Synthesize, Step 4: Students construct an explanation of a related phenomenon of their choosing. "Individually construct explanations of an objects' motion changes. Distribute Model of Collisions or Comic Strip of Collisions or Written Explanation of Collisions to each student. Also, remind students that an important part of their model is to use evidence to support their ideas. To provide evidence students can look back at the list of evidence the class created" (Lesson 12, Teacher Edition)

Students routinely produce artifacts that evidence the use of the grade-appropriate elements of SEPs, CCCs, and DCIs, which are targeted as learning objectives in service of sense-making.

The Lesson Learning Targets and Lesson Assessment Guidance sections in the teacher guide for each lesson include color-coded learning targets, color-coded pieces to look for and listen for, and teacher support for what to do if students are meeting these color-coded goals.
Some examples include:

- Lesson 1, Synthesize, Step 3: Students create a model and put it in their notebook to refer to later. "Develop a model to describe the causes of an object's changes in motion (effect)." (Lesson 1, Teacher Edition)
- Lesson 3, Explore section, Step 2: Students complete an observation chart. "Make observations to serve as evidence for an explanation of the effects of the contact force present when objects collide (cause). (Lesson 3, Teacher Edition)
- Lesson 6: "What will students do?" 6. Evaluate a plan to determine if it is a fair test for investigating how the motion of two objects changes (effect) following a collision (cause). "What to look and listen for during Explore and Connect: evidence that students can identify the variable that will change and variables that

will remain the same in a fair test to investigate how the motion of two objects changes (effect) following a collision (cause) evidence that students can collaboratively evaluate an investigation plan to determine if it is a fair test for collecting evidence to test how and why the motion of two objects changes (effect) following a collision (cause).

- Lesson 7, "What will students do?" 7.A. Carry out a fair test to investigate how the motion of two objects changes (effect) following a collision (cause). "What to look and listen for: evidence that students are changing only one variable (kick size) to investigate how the motion of two objects changes (effect) following a collision (cause).

Key Formative Assessments have been identified as strategies for teachers to support students. Some examples are:

- Lesson 6, Lesson Assessment Guidance, "Assessment Type: Key Formative" "Where to check for understanding: During Explore (slides D) when students individually and collaboratively complete a fair test investigation plan on Colliding Round Objects Investigation Plan." "How can I use this assessment information?" "Students are developing ideas about how to plan and carry out investigations to understand how the motion of objects changes following collisions. Broadening to include a moving object and a stationary object will be important for Lesson 7 when students solidify an understanding that the motion of all objects in a collision changes and that we can see evidence of energy transfer by observing changes in their speed. Use this assessment moment as an opportunity to see where your students are in their learning about planning investigations. The group planning (Explore) and peer review (Connect) serve as an additional scaffold before students plan other investigations later in the unit. Refer to the Following Student Sensemaking for examining students' developing understanding based on students' current sensemaking. The tool can be used as a guide for assessing either group or individual progress, depending upon your assessment needs, and can be used to assess Colliding Round Objects Investigation Plan and Investigation Plan Feedback." (Lesson 6, Teacher Guide)
- Lesson 7, Lesson Assessment Guidance, "Assessment Type: Key Formative" "Where to check for understanding: During Explore (slide B) when students collaboratively carry out a fair test investigation plan using Colliding Round Objects Investigation Plan and Kick Investigation Data." "How can I use this assessment information?: Students are developing ideas about how to plan and carry out investigations to understand how the motion of objects changes following collisions. This is the third opportunity students have had to carry out an investigation, but only the second to carry out a fair test. Broadening to include a moving object and a stationary object in this investigation is important for students to solidify an understanding that the motion of all objects in a collision changes and that we can see evidence of energy transfer by observing changes in their speed. Use this assessment moment as an opportunity to see where your students are in their learning about carrying out investigations. Refer to the Following Student Sensemaking for examining students' developing understanding based on students' current sensemaking. The tool can be used as a guide for assessing either group or individual progress, depending on your assessment needs." (Lesson 7, Teacher Guide)

Suggestions for Improvement: NA

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

The reviewers found extensive evidence that formative assessment opportunities occur throughout the unit, and there are strategies for teachers to use these assessments to evaluate student learning and inform instruction. Support is not explicitly provided to attend to students' individual levels and needs in formative assessments.

All lessons in the unit have formative assessments, and most require three-dimensional thinking. Some ideas for providing feedback are given.

- Teacher Handbook, "Formative assessment opportunities include prompts (verbal, gestures, written) embedded into activities that allow teachers to "quickly" determine whether students are building understanding. These prompts are included in tables that have ideas that teachers should look for and listen for in student responses. There are also suggestions for follow-up questions or prompts for teachers to use to support students' ongoing learning. In addition, at the beginning of each lesson, there is a table that provides information for teachers on how to use the information that they elicit to best support learning." (Teacher Handbook)
- Lesson Assessment Overview, "Each OpenSciEd unit includes an assessment system that offers many opportunities for different types of assessments throughout the lessons. These opportunities include: pre-assessment, formative assessment, summative assessment, peer assessment (called peer feedback with students), and/or self-assessment (called self-reflection with students). Grades K-2 units may only include peer or self-assessment, not always both. Assessment opportunities are embedded and called out directly in the lesson plans. Please look for the yellow "Assessment Opportunity" support in each lesson plan to identify suggested assessments. In addition, there are two tables below that outline where each type of assessment can be found in the unit. The first table, Unit Assessment Plan by Assessment Type, lists the purpose, placement, and tools for each assessment type. The second table, Lesson-by-Lesson Assessment Opportunities, chronologically lists the assessment guidance for each lesson." (Lesson Assessment Overview)
- Lesson 2, Lesson Assessment Guidance, "Look at the types of questions your students have asked with the purpose of determining the support that students may need in upcoming lessons as they work toward asking testable questions that can help them understand cause-and-effect relationships. In particular, look for ways students' questions can be rewritten to be testable and be ready to provide examples as they plan to carry out investigations in subsequent lessons." (Lesson 2, Teacher Edition)
- In Lesson 2, Assessment Opportunity (SEP1.E3, CCC2.E1, DCI 4-PS3.A.1), "Students' questions are an opportunity to gather evidence around Learning Goal 2 with the purpose of determining support that students may need in upcoming lessons around the practice of asking questions, and in particular, asking testable questions that can help them identify cause-and-effect relationships in figuring out ideas about energy and energy transfer. Circulate to listen in on students' partner conversations and keep track of whether or not students are writing open-ended questions. The class will continue to consider how to test their questions as they brainstorm ideas for investigations in the Navigate. Refer to the Assessment Guidance at the beginning of the lesson for more information."
- Lesson 4, Lesson Assessment Guidance, "Use this opportunity to determine the support your students may need around the practice of planning an investigation. It is OK that students are only indicating beginning understanding at this point. Give feedback to students such as pointing out the ideas gathered from the informational text used in the lesson [or] telling them to think of other times in their life when they

need clear directions or procedures to complete a task. This might be an opportunity to think about how procedures show up in their lives outside of science class and make a connection. If you did not get to see/hear ideas from every student in this lesson that is fine, as students will individually and collaboratively plan an investigation again in Lesson 6, which will provide opportunities for more individualized assessment." (Lesson 4, Teacher Edition) It is not clear how individual students get feedback on their thinking.

- In Lesson 5, Assessment Opportunity (SEP6.E2, CCC2.E1, DCI 4-PS3.C.1), "This is an opportunity to formatively assess learning goal 5.B and to provide in-the-moment feedback to support students to construct an explanation using evidence from their investigations. Use the suggestions in the Assessment Guidance at the beginning of the lesson to provide feedback and determine the next steps before students are tasked with individually constructing an explanation in Lessons 7 and 8." (Lesson 5, Teacher Edition).
- Lesson 7, Assessment Opportunity (SEP3.E1, CCC2.E1, DCI 4-PS3.C.1), "Students' individual Kick Investigation Data handouts and the surrounding group discussions provide an opportunity to gather evidence about learning goal 7.A with the purpose of providing feedback to students and guiding instruction in upcoming lessons. Refer to the Following Student Sensemaking tool and the Assessment Guidance at the beginning of the lesson." Teachers are guided on how to evaluate individual student thinking. "Refer to the Following Student Sensemaking for examining students' developing understanding based on students' current sensemaking. The tool can be used as a guide for assessing either group or individual progress, depending on your assessment needs" (Lesson 7, Teacher Edition).
- Lesson 8, Synthesize Section, Step 4, "Construct an explanation that answers our investigation question. Display slide I. Distribute Constructing Explanations to students. Explain to students that they have enough information to explain what happens to the motion of the ball if we change the surface and that when we explain "what" questions in science, we answer them like we do "how and why questions": we need to explain what happened to the motion of the ball and why its motion changed." (Lesson 8, Teacher Edition)
- Lesson 8, Lesson Assessment Guidance, "Look and listen for the ideas your students reference from their investigations to support their explanation in this lesson. Review their explanations on Constructing Explanations and consider providing feedback that helps them to revise their explanations before they are assessed on constructing explanations in Lesson 9." While teachers are prompted to consider providing feedback to help students revise their explanations, there is no guidance for what feedback to provide.
- Lesson 10, Lesson Assessment Guidance, "Use this formative assessment opportunity to see if students need more support in identifying and using evidence to construct explanations. Students have already made progress on this practice to explain changes in the motion of objects related to energy and energy transfer and were assessed in Lesson 9. They will continue to develop this practice in Lesson 11 and will be summatively assessed on it in Lesson 12. However, this is their first opportunity to explain a related phenomenon that they have not investigated in class (in Lesson 2 students explored with marbles, similar to what they observed in their Lesson 9 assessment). Use group discussions and their responses to Sound Explanation to identify where students need support before constructing an explanation in Lesson 11 and being assessed on explaining related phenomena in Lesson 12. Example Sound Explanation reference includes an example of the explanations students may construct." (Lesson 10, Teacher Edition) The class discusses this task as a group, there is no procedure for providing individual feedback.
- In Lesson 11, Assessment Opportunity (SEP1.E3, CCC5.E3, DCI 4-PS3.B.1), "Partnership discussions and Shake-It-Up Investigation handout provides an opportunity to gather evidence about Learning Goal 11 with the purpose of providing feedback and supporting students in making predictions about outcomes that are based on patterns in cause-and-effect relationships students observed in previous investigations. Use this formative assessment opportunity to see if students need more support in making predictions of reasonable outcomes using patterns in cause-and-effect relationships they have observed in previous investigations. Use partnership discussions and their responses on Shake-It-Up Data Table to identify where students need support before being in Lesson 12. As students work with partners to write their predictions,

walk from group to group and listen to their conversations" (Lesson 11, Teacher Edition). This informal method of gathering evidence about student understanding may not give the teacher enough information about which students are in need of additional practice or help.

Some formative assessments attend to individual student needs.

- In the Elementary Teacher Handbook, "Formative assessment opportunities include prompts (verbal, gestures, written) embedded into activities that allow teachers to "quickly" determine whether students are building understanding." (Elementary Teacher Handbook)
- Lesson 3, Lesson Assessment Guidance: "If you notice that students need additional support in understanding that a force is a push or a pull and/or that unbalanced contact forces are involved when the foot/hand and the ball come together, consider using the extension activity provided in the Extension Activity teacher reference. The extension opportunity reinforces 3rd-grade concepts that help build toward the idea that contact forces, such as collisions, transfer energy from one object to the other and result in a change in motion and shape" (Lesson 3, Teacher Edition).
- Lesson 4, Explore Section, Broadening Access, "All students working in groups need opportunities to work with the activity materials. For example, all students need opportunities to manipulate the Kick Investigation System and to make a ball move. Supporting all students engaging in science classroom experiences is important for developing science identities, and is especially critical for those from non-dominant groups (girls, minoritized students of color) that have been historically excluded from science." (Lesson 4, Teacher Edition)
- Lesson 5: "Allow and encourage students to use both content specific and everyday registers when expressing their ideas" (Lesson 5, Teacher Edition)
- Lesson 6, Following Student Sensemaking, "Use this document to monitor students' sensemaking of planning and carrying out investigations, remembering that students often use multiple means of communication at the same time to express their sensemaking. You can use the example table below, a seating chart, your class list, etc. This can be used to monitor group or individual sensemaking." (Lesson 6, Following Student Sensemaking)
- In Lesson 8, Explore Section, Broadening Access, "Consider providing multiple means of representation of the data students have collected in order to support students' sensemaking, such as using different types of graphs and/or "chunking" parts of the graph (by covering some parts) to focus on for each part of the discussion." (Lesson 8, Teacher Edition)

Suggestions for Improvement

- Consider how individual levels of student performance can be identified at different points of the unit through the formative assessment system by creating additional documents like "Following Student Sensemaking" for other important tasks.

III.C. Scoring Guidance — Extensive

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.

The reviewers found extensive evidence that the materials designed to support the evaluation of tasks support the learning process. There is a connection between the assessment activity and the three-dimensional learning goals.

Assessment targets are provided for all formative and summative assessments.
Each formative assessment includes a three-dimensional learning goal.

- Lesson 2, Lesson Assessment Guidance: "Ask questions that can be investigated about the causes of an object's changes in motion (effect)" (Lesson 2, Lesson Assessment Guidance).
- Lesson 5, Lesson Assessment Guidance: "Collaboratively carry out a fair test investigation to produce data to serve as evidence that when objects collide (cause) there are changes in the motion of a ball (effect)" (Lesson 5, Lesson Assessment Guidance).

Guidance for evaluating formative assessments is provided in the document Assessment System Overview.

- Lesson 3, Assessment System Overview: "Assessment Type: Formative
  Where to check for understanding: In the Synthesize, when students revise the Class Consensus Model.
  What to look and listen for:
  - The foot forces (cause) the ball to move (effect).
  - The ball moves (effect) after it is kicked (cause).
  - The kick needs to be hard enough (cause) or needs enough force (cause) to make the ball move (effect).
  - The ball and the shoe change shape (effect) when they are in contact (cause).
  - Also look and listen for how students are making connections between their observations and the evidence they are drawing on to support their revisions to the class consensus model, such as:
  - I saw/felt the beach ball change shape (effect) when my hand hit it (cause). This is evidence that a collision (contact force) causes something to change shape (effect).
  - I saw the ball move (effect) when the foot kicked it (cause). This is evidence that a collision (contact force) causes something to move or change motion (effect).
- Similar guidance is given for each formative assessment in the unit.

In most of the Lesson Assessment Guidance Sections, under the "How can I use this assessment information?", there are suggestions for scaffolds and/or questions a teacher can use as they listen in on small groups or look over individual products. For example:

- In Lesson 4, teachers are provided with the following: "This is the first lesson in this unit where students will consider in-depth the steps we should follow for planning and carrying out investigations. Students will likely have experienced investigating in science class. Use this opportunity to determine the support your students may need around the practice of planning an investigation. It is OK that students are only indicating beginning understanding at this point. Give feedback to students such as: pointing out the ideas gathered from the informational text used in the lesson, telling them to think of other times in their life when they need clear directions or procedures to complete a task. This might be an opportunity to think

about how procedures show up in their lives outside of science class and make a connection." (Lesson 4, Teacher Guide)

Ideas for modification of instruction are found in the section of each lesson called Lesson Assessment Guidance.

- Lesson 3, Lesson Assessment Guidance: "Use the information you gather in two ways: (1) to guide follow-up questions during the discussion in the Synthesize and as the class works to revise the Class Consensus Model, and/or (2) to reinforce 3rd grade concepts. If you notice that students need additional support in understanding that a force is a push or a pull and/or that unbalanced contact forces are involved when the foot/hand and the ball come together, consider using the extension activity provided in the Extension Activity teacher reference. The extension opportunity reinforces 3rd-grade concepts that help build toward the idea that contact forces, such as collisions, transfer energy from one object to the other and result in a change in motion and shape. Students will figure out the role energy plays in Lesson 5" (Lesson 3, Lesson Assessment Guidance).
- Similar guidance is provided for most other formative assessments in the unit.

Scoring rubrics are provided for important sensemaking opportunities. The rubrics include a range of student responses but lack suggestions for what targeted feedback to give students.

- Lesson 9: In the first collision: How does the first marble get started?
    - "Beginning (B) Student responses tend to be one-dimensional. Response uses evidence from the video or past investigations. Example: "I saw the first ball start moving when the launcher hit it." OR response describes that the marble went from not moving to moving. Example: "The first marble started moving because it was hit by the binder/launcher." OR response describes that the object got energy Example: "The marble had no energy and then it got energy."
    - Developing (D) Student responses integrate two dimensions. Response uses evidence of the motion of the marble and connects it to changes in energy. Example: "The moving marble had more energy or the marble got faster because they had more energy." OR response describes the relationship between the energy of the object and the forces acting on it. Example: "The marble started moving faster because it got energy from the push of the binder clip." OR response uses evidence of the motion of the marble to describe changes in speed due to forces acting on the marble. Example: "The marble was not moving, then after it got hit by the binder, it moved for a little, and then it stopped. We saw that pushes can make objects move, like the soccer ball or the puck.
    - Secure (S) Student responses integrate the three dimensions.Response uses evidence of the motion of the first marble and ideas about how forces can cause energy changes to explain why the marble started moving. Example: "The first marble started moving after the collision with the clip. The clip transferred energy to the ball and made the marble go faster." (Lesson 9 Teacher rubric). (Lesson 9, Teacher rubric for Marble Explanation).
    - The rubric lacks suggestions for what targeted feedback to give students.
- Lesson 12: "Question Olivia is learning how to bowl and decides to investigate how and why the force of her throw affects the number of pins she knocks down. Using your understanding of energy and energy transfer and the cause-and-effect relationships we have observed in our unit, what do you predict she will figure out from her investigation?
    - Beginning (B) Student responses tend to be one-dimensional. Response predicts a possible outcome. Example: "Olivia can throw a ball hard to knock down the pins." OR response describes that a collision will happen (without specifying what the collision is) Example: "If the ball is thrown, then there will be a collision." OR response describes that the moving bowling ball has energy (or that the pins get energy, without specifying from where) Example: "The bowling ball has energy." OR "the pins get energy."

- Developing (D) Student responses integrate two dimensions. Response predicts a possible outcome about the changes in energy. Example: "If Olivia throws the ball harder, it will have more energy. OR response predicts that objects will collide Example: "If Olivia throws the ball then it will collide with the pins." OR response says there will be a change in energy when objects collide. Example: "The objects will collide and transfer energy."
- Secure (S) Student responses integrate the three dimensions. Response predicts there will be a change in energy when objects collide. Examples: If Olivia throws the ball harder, then the ball will have more speed and more energy when it collides with the pins. Then, more pins will fall over. If Olivia throws the ball with less force, then she will not knock down a lot of pins. Because the ball will have less speed and less energy to transfer. If the force of her throw is bigger, then it will transfer more energy from her hand to the ball. If the ball has more energy then it has more speed. If it has more speed then it can hit the pins with more energy and knock more of them down.
- The rubric lacks suggestions for what targeted feedback to give students.

Suggestions for Improvement

- Consider including a section on the summative assessment rubrics that outlines strategies for providing feedback to students on their summative assessments.

III.D. Unbiased Tasks/Items — Extensive

Assesses student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.

The reviewers found extensive evidence that tasks that are intended to measure student learning are sensitive to all students. The tasks incorporate multiple ways of communicating, including oral discussions, written explanations, and a choice of writing or making drawings to explain. On a summative task, students have a choice of modalities to express their understanding.

Tasks allow for multiple methods of communication, and vocabulary and text are grade-appropriate.

- Energy Transfer Collisions Unit Front Matter: "In many lessons in this unit, students put a word on the Word Wall. When this happens, teachers are encouraged to introduce the new word and its definition or to co-construct a definition with students. This supports students in practicing with vocabulary, which also supports their sensemaking" (Energy Transfer Collisions Unit Front Matter).
- In Lesson 3, Extension Activity, "The goal of this extension activity is to have students see and discuss multiple images and multiple ideas. Each image may be accurately described with multiple words from the word bank; as you circulate during the activity, encourage students to explain their thinking about why the word they chose describes the image. You may choose to label some of the images with the words from the word bank and display them on your Word Wall, especially if there were some your students were unsure about or if you know that students did not develop the ideas in 3rd grade. See the Lesson Assessment Guidance for more information." (Lesson 3, Extension Activity)

- Lesson 4, Connect Section, Step 3, "Define variable and fair test with students. Display slide N. A variable is something that stays the same or changes in an investigation. Remind students that in the text, we saw that variable was used to describe the materials in a system that can be changed. A fair test is one where we only change one variable at a time and keep everything else the same. Remind students that scientists often use the information learned from a text and apply it to their investigations. Ask students how we could use what we learned in our investigation" (Lesson 4, Teacher Edition).
- In Lesson 5, Synthesize Section, Step 6, "Allow and encourage students to use both content specific and everyday registers when expressing their ideas." (Lesson 5, Teacher Edition)

Tasks provide on-ramping so that all students have the background necessary to complete the task.

- Lesson 1, Connect section, Step 1, "Ask students to think back to a time when they or someone they were watching was playing with a round object, like a ball or puck. Have them think for a moment about that experience. Direct students to use the questions on the slide to turn and talk to a partner about what they or this person was doing with the ball or puck." (Lesson 1, Teacher Edition) The phenomenon used in this unit is framed in a way that includes the experiences of all students.
- Lesson 3, Explore section, Step 2, "Introduce the idea of watching a kick in slow motion. Display slide B. Tell the class that you have a video of someone kicking a ball in slow motion. Discuss how that could be helpful." (Lesson 3, Teacher Edition) The unit uses video that exposes all students to a common experience.
- Lesson 3, in the Materials Section, "If this is your first science unit of the year, create a space in your classroom for the Word Wall. If you already have a Word Wall in your classroom for another subject(s), consider creating a separate space for science words to help students more efficiently use this resource. Locate or print the Word Wall card(s) for this lesson (see the Lesson Vocabulary table). Plan to discuss and post the words during the specified components of the lesson. Alternatively, plan to develop your own Word Wall cards in collaboration with your students. A suggested definition is provided in the teacher guide, but your class may use slightly different language." (Lesson 3, Teacher Guide)
- In Lesson 5, Synthesize section, Step 6, "Define "transfer" and add it to the Word Wall. Summarize that we were talking about the kick giving the ball energy, that the ruler "foot" passed its motion (energy) along to the ball, and then the ball started moving. When scientists talk about energy being the thing that's being given away or passed along or moved from one thing to another, they use the word transfer. Explain that a lot of things can be transferred, like students might transfer books from their backpack to their desk." (Lesson 5, Teacher Edition)
- Lesson 9, Synthesize Section, Step 3, "Remind students that an important part of their explanation is to use evidence from the video, observations they made playing a game of marbles, or observations from their investigations to support their ideas. They should also use the class's Gotta-Have-It Checklist and Class Consensus Model to support their thinking for their explanation. If it's helpful, they can refer to their science notebooks and other class charts, too. Tell students that they can use the word wall, or other references available in the classroom, such as dictionaries or glossaries as resources to spell words correctly in their explanation. Give students about 20-25 minutes to answer the handout questions individually." (Lesson 9, Teacher Guide)
- In Lesson 9, Synthesize Section Step 3, "Individually create models of changes in the marbles' motion. Display slide C. Distribute Model of Marbles Collisons and Investigation Plans. Tell students that they will be using their understanding of how and why an object changes motion and how to plan and carry out investigations to explain how a marble launcher works. Use the video on the slide to introduce what a marble launcher is." (Lesson 9, Teacher Edition) The marble launcher is a related phenomenon, and there is a slide and video to introduce it.

Tasks are introduced, and students express their ideas in a variety of ways. Students have a choice in their expression of ideas in the final task.

- In Lesson 1, Explore section, Broadening Access, "Encourage students to share their thinking in a variety of ways and representations. Validate all the ways we communicate our ideas, such as with gestures or body movements, drawings, and words from any languages your students use." (Lesson 1, Teacher Edition)
- In Lesson 3, Navigate section, step 1, Broadening Access sidebar, "When navigating into and out of lessons, provide multiple means of engagement by connecting to the student-generated Driving Question Board and the Ideas for Investigation chart. This helps to recruit interest because pointing out questions or groups of questions, and/or ideas for investigation that students generated, helps them to value the investigation they are doing in each lesson." (Lesson 3, Teacher Edition)
- In Lesson 3, Synthesize section, Step 6, Students write and draw on their "Growing Ideas Chart," where they record the lesson question, What they figured out in words and pictures, and what new questions they have. (Lesson 3, Teacher Edition)
- In Lesson 7, Synthesize section, Step 4, "Decide as a class to create charts of all our data. Organize students into a scientists' circle with their completed Colliding Round Objects Line Plots. Ask one student from one group to share a sentence that describes their graph (#3 on their handout). This will need to happen for each kick type of line plot. Then, ask if any other groups had a similar description. Ask one group with a similar description to share theirs, and proceed until all groups with similar descriptions have shared. If any groups have a different description, give them an opportunity to share, and proceed through until all groups have shared their descriptions. Then discuss briefly with students what patterns they heard in the descriptions of our line plots." (Lesson 7, Teacher Edition)
- In Lesson 12, Synthesize section, Step 4, "Once students have chosen a phenomenon and an audience, they can then choose a format for their explanation. Their choices include a model, a written story, or a comic strip to construct their explanation." (Lesson 12, Teacher Edition, p12)

Suggestions for Improvement: NA

III.E. Coherent Assessment System — Extensive

Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.

The reviewers found extensive evidence that the unit has a coherent assessment system designed to measure student learning. All assessment tasks provide information about the three-dimensional learning goals and how the assessment furthers student progress toward those learning goals. Different kinds of assessments are used strategically to provide needed feedback to the class.

Each assessment has three-dimensional learning goals.

- In Lesson 2, the three-dimensional learning objective is Ask questions that can be investigated about the causes of an object's changes in motion (effect).
    - Using the Lens of Cause and Effect
    - Students will ask questions and define problems
    - To make sense of: Our initial ideas about why an object's motion changes.

- In Lesson 4, the three-dimensional learning objective is Plan an investigation considering fair tests and controlled variables to produce data using a system whose components collide and cause changes in the motion of a ball.
    - Using the Lens of System and System Models
    - Students will plan and carry out investigations
    - To make sense of: How a collision affects an object's motion

The unit includes pre-assessments, formative assessment, summative assessments, and self assessments.

- In Assessment System Overview, "Each OpenSciEd unit includes an assessment system that offers many opportunities for different types of assessments throughout the lessons. These opportunities include: pre-assessment, formative assessment, summative assessment, peer assessment (called peer feedback with students), and/or self assessment (called self reflection with students). Grades K-2 units may only include peer or self assessment, not always both. Assessment opportunities are embedded and called out directly in the lesson plans. Please look for the yellow "Assessment Opportunity" support in each lesson plan to identify suggested assessments. In addition, there are two tables below that outline where each type of assessment can be found in the unit. The first table, Unit Assessment Plan by Assessment Type, lists the purpose, placement, and tools for each assessment type. The second table, Lesson-by-Lesson Assessment Opportunities, chronologically lists the assessment guidance for each lesson. For more information about the OpenSciEd approach to assessment, visit the OpenSciEd Elementary Teacher Handbook." (Assessment System Overview)

Pre-Assessment

- Lesson 1, Assessment Opportunity, "Pre-assessment: Students' initial models and the initial consensus model they will develop next provide an opportunity to gather evidence around Learning Goal 1 with the purpose of determining support that students may need in upcoming lessons around the practice of modeling, and around ideas of cause and effect, and forces and energy. Students will continue to develop these ideas and practices throughout this unit. Accept all student ideas." (Lesson 1, Teacher Edition)

Formative Assessment

- Lesson 7, Assessment Opportunity, "Key Formative: Students' individual Colliding Round Objects Line Plots handouts and the surrounding group discussions provide an opportunity to gather evidence about learning goal 7.B with the purpose of providing feedback to students and guiding instruction in upcoming lessons. Refer to the Following Student Sensemaking tool and the Assessment Guidance at the beginning of the lesson." (Lesson 7, Teacher Edition)

Summative Assessment

- Lesson 12, Assessment Opportunity, "Summative and Self-Reflection: In this assessment moment for Learning Goals 12.A and 12.B, look for evidence that students can ask question testable questions and predict outcomes based on cause-and-effect relationships they have observed and can explain changes to the object's motion due to energy transfer, including energy transferred to the surroundings as heat and/or sound, and they correctly identify evidence to support their ideas. Consider providing feedback to students using Teacher Rubric for Explanations of Collisions and giving them an opportunity to revise their responses. Refer to the Teacher Rubric for Explanations of Collisions tool and the Assessment Guidance at the beginning of the lesson for more information." (Lesson 12, Teacher Edition)

Self Assessment

- In Lesson 9, Assessment Opportunity, "Self-assessment: Students' use of Self-Assessment provides an opportunity for students to reflect on their progress concerning learning goals 9.A. and 9.B, to help them identify improvements they can make the next time they are asked to complete similar tasks. Consider using the self-assessment in combination with Teacher Rubric for Marbles Explanation to provide feedback to students on Model of Marbles Collisons."

Assessment tasks work together to form a coherent system to evaluate student thinking.

- In the Elementary Teacher Handbook, "All OpenSciEd elementary curriculum units have assessment opportunities woven throughout the lessons to support teachers in being responsive to students' ideas and to support students in building their science understandings. These assessment opportunities encourage multimodal communication such that students have many different ways of demonstrating their ongoing sensemaking. Teaching tips and other educative features include prompts and questions to increase participation for traditionally minoritized learners within the whole class and cooperative learning groupings." (Elementary Teacher Handbook)

Suggestions for Improvement: NA

III.F. Opportunity to Learn	Adequate
Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback.	

The reviewers found adequate evidence that students have multiple opportunities to show their understanding, receive feedback on their thinking, then have another opportunity to revise and show their new learning. Students have opportunities to become proficient in PE 4-PS3-1 as they write explanations, receive feedback, then have additional tasks, including assessment, to demonstrate their understanding. For PE 4-PS3-3, students consider testable questions and make predictions in several tasks. Individual feedback is limited, and students are expected to write their own questions and make predictions on the summative assessment.

Students have multiple opportunities to use the SEPs, DCIs, and CCCs to understand targeted learning.

Evidence from the materials where the criterion was met,

4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object. Lesson 3 Learning Goal - Make observations to serve as evidence for an explanation of the effects of the contact force present when objects collide (cause).

- Lesson 3, Synthesize section, Step 3: "As students build understanding, prompt them for evidence that supports their explanations. What caused the ball to start moving in the first place? What is the effect of kicking the ball? How does kicking the ball make it move?" (Lesson 3, Teacher Edition) Students receive feedback on their thinking in the class discussion of these prompts.

Lesson 5 Learning Goal - Use evidence to construct an explanation that when a foot and ball collide with force, energy is transferred and the ball's motion changes.

- Lesson 5, Synthesize section, Step 6: "Construct an explanation to answer our investigation question. Display Slide K. Using the prompts on the slide, come to consensus with students on what we have figured out based on the evidence we collected in our fair test investigations. As they share their oral explanations, consider jotting them down on a whiteboard, chart, or digital space" (Lesson 5, Teacher Edition).
- Lesson 5, Lesson Assessment Guidance: "Use this formative assessment opportunity to see if students are making progress towards understanding what is evidence of energy transfer between objects. Although this is a group discussion and activity, students will have additional individual opportunities in lessons 7 and 8 to continue developing an understanding of constructing explanations from evidence about energy and energy transfer that happens in collisions. Use the discussion in this lesson to identify where your class may need support as they transition to individual explanations in Lesson 7. You can support them by using the follow-up discussion prompts provided in Synthesize. Also, if you notice during the discussion that students need support to use evidence in their explanations, consider demonstrating your thinking aloud as you construct your own explanation" (Lesson 5, Teacher Edition).

Lesson 7 Learning Goal - Use evidence to construct an explanation that the faster the moving ball is going, the more energy it has.

- Lesson 7, Synthesize section, Step 4: "Distribute Construct an explanation about energy during a collision and ask students to write in their own words, or draw what we now know about collisions and energy transfer" (Lesson 7, Teacher Edition).
- Lesson 7, Lesson Assessment Guidance: "This is the second opportunity students have had to construct an explanation in this unit. Use this as a formative assessment moment to determine if your students are making progress in using evidence to support their how and why explanations. Refer to the Following Student Sensemaking for examining students' developing understanding based on students' current sensemaking. The tool can be used as a guide for assessing either group or individual progress, depending on your assessment needs" (Lesson 7, Teacher Edition).

Lesson 8 Learning Goal - Use evidence to support an explanation that contact forces transfer energy, which changes the ball's motion.

- Lesson 8, Synthesize section, Step 4: "Construct an explanation that answers our investigation question. Display slide I. Distribute Constructing Explanations to students. Explain to students that they have enough information to explain what happens to the motion of the ball if we change the surface and that when we explain "what" questions in science, we answer them like we do "how and why questions": we need to explain what happened to the motion of the ball and why its motion changed" (Lesson 8, Teacher Edition).
- Lesson 8, Lesson Assessment Guidance: "Review their explanations on Constructing Explanations and consider providing feedback that helps them to revise their explanations before they are assessed on constructing explanations in Lesson 9" (Lesson 9, Teacher Edition).

Lesson 9 Learning Goal - Use evidence to construct an explanation relating the speed of an object to the energy of that object.

- Lesson 9, Synthesize section, Step 3: Students individually complete Model of a Marble Collision. "Remind students that an important part of their explanation is to use evidence from the video, observations they made playing a game of marbles, or observations from their investigations to support their ideas. They should also use the class's Gotta-Have-It Checklist and Class Consensus Model to support their thinking for their explanation." (Lesson 9, Teacher Edition).

- Lesson 9, Lesson Assessment Guidance: "This assessment is a formal opportunity to gather summative individual information about your students' progress. Students have had multiple opportunities in this unit to construct explanations relating the speed of an object to the energy that it has and to identify evidence that energy transfer has occurred, so the Model of Marbles Collisions can be used as a summative assessment opportunity. Students will also have an opportunity to reflect on and assess their own learning on Self-Assessment. Use the Teacher Rubric for Marbles Explanation to support your evaluation of students' materials. Consider allowing them to revise their explanations using the feedback provided to them. Opportunities to revise explanations will provide students with additional support in making progress on their understanding of how to use evidence to construct explanations of energy and energy transfer between objects. Students will have another formal assessment opportunity to construct an explanation based on evidence in Lesson 12 including additional evidence for energy transfer due to sound and heat" (Lesson 9, Teacher Edition)

Lesson 12 Learning Goal - Use evidence to construct an explanation relating the speed of an object to the energy of that object

- Lesson 12, Synthesize section, Step 4: "Individually ask questions and construct explanations. Display slide F. Distribute Collisions: Graphic Question Organizer or Collisions: Written Explanation or Collisions: Comic Strip to each student. Remind students that an important part of their explanation is to use evidence to support their ideas. To provide evidence students can use their observations from their investigations, their Class Consensus Model, and their Gotta-Have-It Checklist. Point out to students that for Part A they are addressing questions about bowling. For Part B, they are explaining a phenomenon of their choice. Have students write down their choice on the provided blank in part B. Then give students approximately 30-35 minutes to complete their assessments" (Lesson 12, Teacher Edition).
- Lesson 12, Lesson Assessment Guidance: "This assessment is a formal opportunity to gather summative information about your students' progress. This is the final formal assessment opportunity for constructing explanations based on evidence in this unit. Students have had multiple opportunities throughout the unit to construct explanations of changes in energy that result from forces and energy transfer, and this assessment asks them to transfer their understanding to a related phenomenon of their choice. Students will also have an opportunity to reflect on and assess their own learning on Student Self-Reflection. Use the Teacher Rubric for Explanations of Collisions to support your evaluation of students' materials and to provide them with feedback. Consider giving students an opportunity to revise their explanations using the feedback provided to them. Opportunities to revise explanations will provide students with additional support in making progress on their understanding of the performance expectations students made progress on in this unit" (Lesson 12, Teacher Edition).

4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide.
Lesson 2 Learning Goal: "Ask questions that can be investigated about the causes of an object's changes in motion (effect).' (Lesson 2, Teacher Guide)

- Lesson 2, Synthesize section, Step 4: "Prompt students to look back at the charts where you've collected observations about the motion of soccer balls, hockey pucks, and marbles to help them think of questions they have. Slide M has helpful prompts for students to use when writing their questions, such as: How does ____ cause the ____ to ____? Why does ____ cause the ball/puck/marble to ____? If we do ____, how will the ball's/puck's/marble's motion change? What happens if we do ____?" (Lesson 2, Teacher Edition)
- Lesson 2, Lesson Assessment Guidance: "Use this information to uncover students' initial ideas about the kinds of questions they can ask about changes in an object's motion. This is not an opportunity to take a grade or score. You will have a chance to further clarify and discuss questions as you organize the Driving Question Board (DQB) and support students in generating ideas for investigation. Encourage students to

rewrite their questions to become more open-ended, particularly if their questions can best be answered with a "yes" or "no". Their questions could begin with a "How" or "Why" and/or follow the structure of the prompts provided on slide M. As the class progresses through the unit, students will continue to use the questions placed on the Driving Question Board as they build understanding of what a testable question is (Lesson 4) and continue to plan investigations of testable questions (Lessons 6, 8, 10, and 11). Look at the types of questions your students have asked with the purpose of determining the support that students may need in upcoming lessons as they work toward asking testable questions that can help them understand cause-and-effect relationships. In particular, look for ways students' questions can be rewritten to be testable and be ready to provide examples as they plan to carry out investigations in subsequent lessons" (Lesson 2, Teacher Edition).

Lesson 4 Learning Goal - Carry out a fair test to investigate how the motion of two objects changes (effect) following a collision (cause).

- Lesson 4, Navigate section, Step 1: "Identify testable and nontestable questions on our DQB. Display slide E. Have student pairs review the questions they identified are related to what we are wondering about and determine if they are testable or not. Remind students that it is okay if they are not, because we might still be able to gather evidence from a nonfiction book or talk to scientists to answer them. Using the prompts on the slide, have students mark the questions they think are testable" (Lesson 4, Teacher Edition). Students receive only whole class feedback as the class decides on a testable question.
- Lesson 4, Synthesize section, Step 4: "Display slide L. Tell students we will use our experiences and ideas we have figured out to make predictions about how and why the motion of two colliding balls changes after a collision. Explain to students that good predictions will describe what we think we will observe and why. Scientists often think about cause-and-effect relationships when they make a prediction. Have students briefly turn and talk with a partner about the variable they are testing (a cause) and what they think its effect will be. Ask a few students to share with the class what they discussed. Then, suggest to students that since we are changing kick size to understand how a second ball moves when there is a collision, we start our prediction with "If we change the kick size, then the second ball will…." Have students jot down the rest of their predictions under the testable question on their Colliding Round Objects Investigation Plan handout. Then have students turn and talk with a partner about their prediction before briefly sharing their predictions with the class. Accept all responses, but encourage students to use evidence from their last investigation to support their prediction" (Lesson 4, Teacher Edition)
- Lesson 4, Lesson Assessment Guidance: "Refer to the Following Student Sensemaking for examining students' developing understanding based on students' current sensemaking" (Lesson 4, Teacher Edition). The tool teachers use to evaluate student understanding, Following Student Sensemaking," does not have specific references for writing testable questions or making predictions.

Lesson 6 Learning Goal: "Evaluate a plan to determine if it is a fair test for investigating how the motion of two objects changes (effect) following a collision (cause)." (Lesson 6, Teacher Edition)

- Lesson 6, Explore Section, Step 2: The class reviews what they understand about collisions before asking questions. "Summarize what students noticed and how they might use the frames for the testable questions to re-write their DQB questions, how they can identify the components and variables, and what they need to remember for analyzing their data. Point out to students that predictions are important, too, and we'll work on that together as a class later in this lesson. We can only make a prediction once we know what our testable question is." (Lesson 6, Teacher Guide) Students receive no feedback on their questions.

Lesson 8 Learning Goal - Use evidence to support an explanation that contact forces transfer energy, which changes the ball's motion.

- Lesson 8, Navigate section, Step 1: "Develop a testable question to guide our investigation. Briefly read questions related to changing surfaces on our Driving Question Board, the testable questions we have investigated so far, and our Ideas for Investigation. As a class come up with a testable question that could guide our investigation today, something similar to "What happens to the motion of the ball if we change the surface?" (Lesson 8, Teacher Edition). The class completes this together, and individual students receive no feedback about their ideas.
- Lesson 8, Explore section, Step 2: "Remind students that scientists make predictions based on prior knowledge from experiences and observations they have made. Give students time to think about a prediction and to jot down their predictions on their handouts. Ask students to share their ideas with the class" (Lesson 8, Teacher Edition). No feedback has been provided for this task.

Lesson 10 Learning Goal: "Identify the evidence that supports particular points in an explanation of objects colliding and energy being transferred to the surroundings as sound." (Lesson 10, Teacher Edition)

- Lesson 10, Navigate Section, Step 1, "Remind students that we also created a testable question that would help us explore why we hear sound when a ball collides with a foot. Review the question with students and then use the prompts on the slide to make predictions about how and why sounds are produced in a collision. Give students 1-2 minutes to discuss with a partner before having them share their ideas with the class. Encourage students to use the "If…then…because…" sentence frame they have used in other investigations to make predictions." (Lesson 10, Teacher Guide). Before generating questions, the class discusses causes and effects they have noticed in previous investigations and evidence that energy is transferred in a collision. The testable question has been determined in advance and is printed on the student handout.
- Lesson 10, Navigate section, Step 1: "Review the question with students and then use the prompts on the slide to make predictions about how and why sounds are produced in a collision. Give students 1-2 minutes to discuss with a partner before having them share their ideas with the class. Encourage students to use the "If…then…because…" sentence frame they have used in other investigations to make predictions. Jot down their predictions on a whiteboard, chart paper, or digital space for students to refer to throughout the lesson. If necessary, refer to Fair Test Investigation Infographic" (Lesson 10, Teacher Edition). Although the class discusses this, individual students do not receive feedback on their predictions.

Lesson 11 Learning Goal - Ask questions that can be investigated to predict reasonable outcomes about heat as evidence of energy transfer when objects collide.

- Lesson 11, Explore section, Step 3: "Decide what our testable question will be for this investigation. Have students look at their DQB questions about heat, and the question frames on their Fair Test Investigation Infographic. Then, have students turn and talk with a partner. As a class, decide on a question that is similar to how and why does the temperature of an object change after a collision?" Students work in pairs to come up with their own testable question, but there is no feedback given, and students all use the question that the class has already determined with the guidance of the teacher.
- Lesson 11, Explore section, Step 3: "Make predictions of what we think will happen in our investigation. Display slide I. If students have not yet done so, have them jot down their investigation question on their Shake-It-Up Investigation handout" (Lesson 11, Teacher Edition).
- Lesson 11, Lesson Assessment Guidance: "Use this formative assessment opportunity to see if students need more support in making predictions of reasonable outcomes using patterns in cause-and-effect relationships they have observed in previous investigations. Use partnership discussions and their responses on Shake-It-Up Data Table to identify where students need support before being in Lesson 12" (Lesson 11, Teacher Edition).

Lesson 12 Learning Goal: "Ask questions and predict outcomes about the changes in energy that occur when objects collide" (Lesson 12, Teacher Edition)

- Lesson 12, Synthesize Section, Step 4, "Individually ask questions and construct explanations. Display slide F. Distribute Collisions: Graphic Question Organizer or Collisions: Written Explanation or Collisions: Comic Strip to each student. Remind students that an important part of their explanation is to use evidence to support their ideas. To provide evidence students can use their observations from their investigations, their Class Consensus Model, and their Gotta-Have-It Checklist. Point out to students that for Part A they are addressing questions about bowling. For Part B they are explaining a phenomenon of their choice. Have students write down their choice on the provided blank in part B. Then give students approximately 30-35 minutes to complete their assessments." (Lesson 12, Teacher Guide)
- Lesson 12, Lesson Assessment Guidance, What to look and listen for, "Look for evidence that students have written testable questions about changes in energy that occur when objects collide with different surfaces. These questions should involve the relationship between two variables. Students should also make predictions that focus on expected changes in motion or the causes of energy transfer in the system." (Lesson 12, Teacher Guide)

Suggestions for Improvement

- Consider adding specific feedback about writing testable questions and making predictions to the document "Following Student Sensemaking" so that students receive feedback on their thinking.

CATEGORY RATINGS			Total Score
CATEGORY I: NGSS 3D Design	CATEGORY II: NGSS Instructional Supports	CATEGORY III: Monitoring NGSS Student Progress	
0 1 2 (3)	0 1 2 (3)	0 1 2 (3)	9

Overall ratings: The score total is an approximate guide for the rating. Reviewers should use the evidence of quality across categories to guide the final rating. In other words, the rating could differ from the total score recommendations if the reviewer has evidence to support this variation.	**E: Example of high quality NGSS design**–High quality design for the NGSS across all three categories of the rubric; a lesson or unit with this rating will still need adjustments for a specific classroom, but the support is there to make this possible; exemplifies most criteria across Categories I, II, & III of the rubric. (total score ~8–9) **E/I: Example of high quality NGSS design if Improved**–Adequate design for the NGSS, but would benefit from some improvement in one or more categories; most criteria have at least adequate evidence (total score ~6–7) **R: Revision needed**–Partially designed for the NGSS, but needs significant revision in one or more categories (total ~3–5) **N: Not ready to review**–Not designed for the NGSS; does not meet criteria (total 0–2)	**Overall rating below:** **E**