Chain Reaction: Energy in Motion

DEVELOPER: NGSS Early Implementers

GRADE: 4 **|** **DATE OF REVIEW:** June 2021

Educators Evaluating Quality Instructional Products

Chain Reaction

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL RATING: R

TOTAL SCORE: 4

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

Click here to see the scoring guidelines.

This review was conducted by NextGenScience using the EQuIP Rubric for Science.

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

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EQuIP RUBRIC FOR SCIENCE EVALUATION

Summary Comments

Thank you for your commitment to students and their science education. NextGenScience is glad to partner with you in this continuous improvement process.

The unit scored highly on many of the individual criteria and includes several features critical to NGSS design. For example, students have opportunities to develop and use many elements from the three dimensions throughout the unit, and students are explicitly guided in building in understanding of several Crosscutting Concept elements. Students have multiple opportunities to express their ideas and generate many artifacts that show their use of multiple dimensions together in service of sense-making and problem solving.

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

- **Modifying the phenomena and problems claimed in the unit.** Currently, there is a mismatch between what the materials claim are the phenomena and problems that drive learning, and what actually drives learning. Changing some of these claims and clarifying some of the driving phenomena and problems for students could help increase opportunities for sense-making and problem solving throughout the learning sequence.
- **Building a formative assessment process.** Currently, there are many places that are identified as formative assessment opportunities throughout the learning sequence. Building out a full formative assessment process so that there is guidance for a range of student responses and how instruction could be modified based on student responses would be helpful.
- **Providing scoring guidance.** Although expected student responses are included throughout the unit, scoring guidance that can help teachers interpret student progress for all three dimensions is not provided. Including scoring guidelines for a range of student responses for all three dimensions that show teachers how they can interpret student progress and including example student models could help teachers monitor student progress.

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

CATEGORY I

NGSS 3D DESIGN

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

Chain Reaction

EQuIP RUBRIC FOR SCIENCE EVALUATION

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

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.

Rating for Criterion I.A. Explaining Phenomena/Designing Solutions	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that learning is driven by students making sense of phenomena or designing solutions to a problem. The general topic of Rube Goldberg machines provides a common thread throughout the unit, and the focus of most of the lessons is to support students in making sense of investigative phenomena or designing solutions to problems. However, there is a slight mismatch between what the unit materials claim as anchor and investigative phenomena and what drives the learning for some parts of the unit. Also, students do not connect their learning back to explain all of the phenomena presented to them, and some of the phenomena and problems used do not build on each other coherently.

The anchoring phenomenon is stated as “a Rube Goldberg machine stalls” (page 17). However, this phenomenon does not drive learning for the entire unit, as students are not introduced to this problem until Lesson 4.2, and only Lessons 2 and 3 really focus on explaining this phenomenon. Instead, the general topic of Rube Goldberg machines provides a common thread throughout the unit.

An investigative phenomenon or problem is identified for each of the five lessons. However, not all of the stated phenomena are actually true phenomena, and students do not come back to fully explaining or designing solutions for all of the phenomena and problems presented to them in the unit.

- The Lesson 4.1 Investigative Phenomenon is stated as “In a Tom and Jerry cartoon, objects in a chain reaction move with one initial contact” (page 17).
  - In Step #1, students are first presented with a scenario that sets up the problem that the people in the scenario have mice in their pantry and that they need to get rid of them (page 20). Students are asked to discuss what criteria would make a good mousetrap and then are shown a Tom and Jerry cartoon video in Step #4 (page 20). In Step #5, students share their observations of the video and then discuss if the mousetrap in the video met the criteria. The problem in this scenario seems to drive the lesson initially, although this is not recognized as the driver on page 17. In Step #6, students are asked “to consider what happened and if they could make the trap better” (page 21). Students

are then shown the *Tom and Jerry* video about a Rube Goldberg machine, and the focus then switches to students trying to explain what is happening in the reactions of the Tom and Jerry mousetrap. Students do not return to solving the problem presented to them in the original scenario. However, the common topic of Rube Goldberg and trying to figure out how the machine works is present for all parts.

- The Lesson 4.2 Investigative Phenomenon is stated as "A Rube Goldberg machine stalls when the paper roll doesn't knock over the glass" (page 28).
    - In Steps #4–7, students watch *Audri's Rube Goldberg Monster Trap* video, and then are asked to "discuss why the Rube Goldberg machine stalled" and to share their questions and wonderings (page 31).
    - The lesson focuses on students comparing the successful vs. failed attempts and looking at the differences between the two and trying to figure out how energy is involved. While most of the lesson implies to students that they will be designing a solution to the failed Rube Goldberg steps, that itself does not happen in this lesson, and it is not made clear to students if they will be designing the solution in future lessons. Instead, the lesson jumps back to connect to the Tom and Jerry cartoon.
    - At the end of the lesson, in Step #24, students are told "they are going to have an opportunity to apply what they learned in this lesson to Lesson 1" (page 35). Students re-watch the *Tom and Jerry* video and "identify observable changes in the system that provides evidence that energy is present" (page 35).
- The Lesson 4.3 Investigative Phenomenon is stated as "In a Rube Goldberg machine, moving objects collide with stationary objects" (page 43). However, this does not drive the lesson, and does not match what students figure out in the lesson.
    - Based on the student questions that the teacher refers to in Step #1, (What do we need to do to make the failed one work? If I make it go faster, could it work? How can I give it more energy so it will not stall?) the focus of the lesson from the beginning seems to be to figure out how to fix the failures of Audri's Rube Goldberg machine from Lesson 4.2. For example, in Steps #3–6, students engage in "constructive playtime" as they explore ways that the given materials interact and then record their observations as evidence to support them as they figure out why the Rube Goldberg machine stalled. However, this does not match what is claimed on page 43 as being the investigative phenomenon/problem.
    - The exit ticket asks students to respond to the prompt "Ivan and Alyssa want to fix the stalled Rube Goldberg machine that traps the monster. How can they use what they learned today to make the Rube Goldberg machine successful? Cite evidence from your explanations to support your solution" (page 50).
- The Lesson 4.4 Investigative Phenomenon is stated as "Energy transfers can be observed in parts of a Rube Goldberg machine where energy converts its action to movement, sound, electricity" (page 69). As stated, this is not a phenomenon. The general topics of energy transformation and Rube Goldberg drive this lesson, instead of sense-making and problem solving.
    - In Steps #4–5, students are shown a video of a different Rube Goldberg machine, the *3M Rube Goldberg* machine, and are asked if their claims about how energy is

transferred can explain everything they just observed in this new video, and if not, what they still need to figure out (pages 73–74).

  - In Step #7, students review their models from Lesson 2 and look at what they can add to their model in terms of energy being transformed (page 74). Students watch and revisit the successful attempts of Audri's Rube Goldberg, so they do not connect back to designing a solution to the non-working parts as originally introduced in Lesson 2.
  - In Step #32, students watch the *3M Rube Goldberg* video again and discuss how their claim and evidence statements can help them explain the flow of energy in the machine (page 79).
- The Lesson 4.5 Identified Problem is stated as "Use a Rube Goldberg machine to solve a class problem" (page 96).
  - In Steps #2–3, students are asked to write or draw three ways in which energy transfers or transformations are useful in their everyday life and the teacher is told to listen for ideas that can be stated as problems to be solved (page 99). The teacher is told to "select those ideas to discuss further, and/or select a couple of the ideas ESRs: *Turn on lights in a dark room*. Then work with the class to restate them as a problem to be solved *(e.g., a movie is playing but no one can see it because the lights are too bright.)* Chart the problems to be solved."
  - The teacher chooses a problem in the classroom that students will design a Rube Goldberg machine to solve.

Student questions are elicited at several points in the unit and some of the questions are used to drive learning in the unit. In the Advance Preparation for Lesson 1, the teacher is instructed to create a chart that records student questions throughout the unit, called the *Our Questions* chart. However, students are presented with several possible phenomena and problems, and questions for many of them are all recorded on the *Our Questions* chart, without any seeming distinction as to which questions are associated with explaining which phenomenon or problem.

- In Lesson 4.1 Step #5, after students watch the Tom and Jerry video, students are asked what questions they have and what they are wondering about (page 21). It is not clear if these questions will be used to drive any of the learning.
- In Lesson 4.1 Step #15, students are asked to individually think about any questions they have about the Tom and Jerry mousetrap. The teacher charts the questions as they share out loud and then discusses which of the questions might lead to an investigation and records them in the *Our Questions* chart (page 22). The teacher is instructed to build on any questions that ask about energy (page 23).
- At the beginning of Lesson 4.2, the class reviews the questions from the *Our Questions* chart, and the teacher is told to look for questions such as "do things like this happen in real life? Does it always work?" (page 31). Students are told they will have an opportunity today to answer their questions.
- In Lesson 4.2 Step #7, after students watch *Audri's Rube Goldberg Monster Trap* video, they share their questions and their responses are charted by the teacher on the *Our Questions* chart

(page 31). In Step #8, the teacher is guided to look on the chart for questions such as "why did it work in some places and not in others?" (page 32).
- In Lesson 4.2 Step #22, students share what questions they have about the Rube Goldberg machine (page 35). These questions are charted on the *Our Questions* chart.
- At the beginning of Lesson 4.3, the teacher refers back to the *Our Questions* chart and points out questions such as "what do we need to do to make the failed one work? If I make it go faster, could it work?" (page 46). Students are asked to work with partners to discuss their ideas to answer these questions.
- In the Advance Preparation section for Lesson 4.4, the teacher is instructed to make a chart titled *Questions about Rube Goldberg Machines* (page 72). In Step #5, after students watch the *3M Rube Goldberg Machine* video, their questions about the rube Goldberg are recorded on this chart. However, these questions are not explicitly used to motivate sense-making and are not referred back to.
- At the beginning of Lesson 4.5, the teacher reviews the *Our Questions* chart looking for anything related to how energy is transferred/transformed in daily lives.

Students' prior experiences related to the phenomena/problems in the unit are not explicitly elicited. Some examples include:
- At the beginning of Lesson 4.1, when students are asked to discuss what criteria would make a good mousetrap, they may be pulling on their prior experiences, although they are not explicitly asked to do so.
- In Lesson 4.1, when students contribute to the *Our Questions* chart, they may be developing questions based on their prior experiences, but they are not explicitly asked to do so.

Suggestions for Improvement
- To make the claim of the anchor phenomenon more accurate, consider the following:
    - Describing the phenomenon as an investigative phenomenon instead of an anchor phenomenon.
    - Introducing the anchor problem of a "Rube Goldberg machine stalls" in Lesson 4.1 instead of Lesson 4.2 so that it anchors the entire unit instead of a just a few lessons.
    - Modifying Lesson 5 so that students design a solution to solve the problem with Audri's Rube Goldberg machine instead of creating a new problem to solve. This could help students make connections back to a problem that was presented to them earlier in the unit.
- Consider changing some of the investigative phenomena for lessons that are not truly phenomena. Not all lessons need an investigative phenomenon or problem, and they can be focused on directly explaining the anchor phenomenon or solving the anchor problem instead.
- Consider helping students see the connections between what they are learning and what they are trying to explain or solve. Currently, several different phenomena and problems are introduced to students, but they do not always come back to fully solve or explain all of them. It may not be clear to students which phenomenon or problem they are focusing on solving or explaining at all times. Providing guidance for setting up the *Our Questions* chart and perhaps

having it be sectioned to track questions separately for each phenomenon or problem could be helpful. This way students would be able to see if they are addressing all of their questions for a specific phenomenon or problem.

- Consider providing students with opportunities to explicitly think about their prior experiences and to generate questions based on these experiences.

I.B. THREE DIMENSIONS

Builds understanding of multiple grade-appropriate elements of the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) that are deliberately selected to aid student sense-making of phenomena and/or designing of solutions.

i. Provides opportunities to *develop and use* specific elements of the SEP(s).
ii. Provides opportunities to *develop and use* specific elements of the DCI(s).
iii. Provides opportunities to *develop and use* specific elements of the CCC(s).

Rating for Criterion I.B. Three Dimensions	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions. Students have opportunities to develop and use many, but not all, of the claimed SEP, DCI and CCC elements.

Science and Engineering Practices (SEPs) | **Rating: Adequate**

The reviewers found adequate evidence that students have the opportunity to use or develop the SEPs in this unit. Students have opportunities to develop and use many SEP elements, but not all of the elements that are claimed for each lesson.

Asking Questions and Defining Problems

- *Ask questions about what would happen if a variable is changed.*
    - Claimed for Lesson 4.3. However, no evidence was found of student use or development of the element.
- *Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.*
    - Part of this element is claimed for Lesson 4.1 *"ask questions that can be investigated."* In Step #15, students are asked to think about and then share any questions they have about the Tom and Jerry cartoon mousetrap (page 22). Then in Step #16, the teacher

discusses which of the questions might lead to an investigation that would help students to understand their observations (page 22).
  - Claimed for Lesson 4.2. Students ask questions in Steps #7 and 22, but they are not guided or directed to ask questions that can be investigated, so they are not developing or using this element.
  - Claimed for Lesson 4.3. In Step #23, students use the first part of this element when they are asked to "use their previous claim to generate testable questions about this system of objects" (page 50). Students do not develop an understanding of the second part of this element, "predict reasonable outcomes…"
- *Define a simple design problem that can be solved through the development of ~~an object,~~ tool, ~~process, or system~~ and includes several criteria for success and constraints on materials, time, or cost.*
  - Claimed for Lesson 4.5. In Steps #2–3 the students share ideas about which energy transfers or transformations are useful in their everyday life and the teacher is told to listen for ideas that can be stated as problems to solve. The teacher works with the class to restate ideas as problems to be solved (page 99). In Step #6, the class identifies the problem they will solve in this lesson (page 100). In Step #9, students are asked to share their ideas for the criteria and constraints for the design.

Developing and Using Models

- *Develop a diagram or simple physical prototype to convey a proposed object, tool, ~~or process.~~*
  - Claimed for Lesson 4.5. In Steps #10–14, students work in groups to create a drawing of their design idea (a type of Rube Goldberg machine) that can solve the problem (page 101). In Step #15, students build their design (page 102).
- *Develop and/or use models to describe and/or predict phenomena.*
  - Claimed for Lesson 4.1. In Step #13, students are asked to "create a model of one section of the mousetrap that involves at least 3 changes" (page 22).
  - Claimed for Lesson 4.2. In Steps #19–21, students create a model to show how *Audri's Rube Goldberg* operates (pages 34–35). They are asked to think about where the energy came from, what it did and where it went.

Planning and Carrying Out Investigations

- *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 for Lesson 4.3. In Step #7, students are asked how they can investigate the relationship between the speed of an object and the energy it possesses (page 47). The *Teacher Note* states what students should already know about planning investigations if they have done so before, and also states that "if this is the students' first attempt at planning an investigation, take the time to help students understand these components of planning an investigation." In Steps #8–11, the teacher helps guide students to think about an investigation plan and the class collaboratively decides on an investigation plan to use (pages 47–48).

- *Make predictions about what would happen if a variable changes.*
  - Claimed for Lesson 4.3.
    - In Step #9c, students are asked "what would happen if you change the speed of the objects," when they are planning the investigation. This gets students started thinking about what would happen if speed changes in their plan (page 47). Then, in Step #11b, students predict if they think height will make a difference in how far their object travels when it goes down a ramp (page 48).
- *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 for Lesson 4.3. In Step #11, students plan their investigation and figure out how they will collect their data (page 48). Students collect and record data in Step #13 and then record their data on a class data chart in Step #15 (page 49). Students conduct the investigation to gather evidence to be able to solve a problem.
  - Claimed for Lesson 4.4. Students make observations as they rotate through the four stations and record their observations on the *Energy Transformation Data Sheet* for the station (pages 82–85). Students try to gather data to explain energy transformations. The teacher conducts a brief conversation "about the difference between data and evidence" in Step #20 (page 77). Students make observations to explain mini-phenomena at each station, but their overall goal is to explain the topic of energy transformations.
  - Claimed for Lesson 4.5. In Steps #15–16, students build their Rube Goldberg machine and make observations and record data to test their design (page 102).

Analyzing and Interpreting Data

- *Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships.*
  - Part of this element is claimed for Lesson 4.2. *Represent data in ~~tables and/or~~ various graphical displays ~~(bar graphs, pictographs, and/or pie charts)~~ to reveal patterns that indicate relationships.* However, no evidence was found of student use or development of the element.
  - This element is not claimed for Lesson 4.3, but in Steps #15–16, students create a class data chart and then discuss what patterns they notice and what this pattern may imply (page 49).
- *Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and or/computation.*
  - Claimed for Lesson 4.3. In Steps #16–19, students complete analysis questions on their *4.3.C1: Analyze Data Questions* worksheet to make sense of the relationship between energy and speed. They refer back to the question that they are trying to answer and think about if there is enough evidence to support their claim (pages 49–50).
  - Claimed for Lesson 4.4. Students are provided with the *Sentence Frames for Analyzing Our Data* worksheet (page 92) to use as a guide to share their data in Step #21 (page 78). Students use *4.2.C1: Energy Questions* (page 28) to help them analyze their data

(pages 78–79). However, they use this data to make a claim about energy transformations, not necessarily to explain a phenomenon.

- *Use data to evaluate and refine design solutions.*
  - Claimed for Lesson 4.5. In Steps #15–16, students build and test their Rube Goldberg designs and they are encouraged to note "what works and what needs adjustment" (page 102). Then, students partner with other groups to discuss the strengths and limitations of their designs and share suggestions for improvements of their design (page 102).
- *Compare and contrast data collected by different groups to discuss similarities and differences in their findings.*
  - Claimed for Lesson 4.4. In Step #21, students share the data that they collected from each station. Students are encouraged to "identify the patterns in the cause and effect relationship of what they observed" (page 78).

Constructing Explanations and Designing Solutions

- *Apply scientific ideas to solve design problems.*
  - Claimed for Lesson 4.5. In Steps #10–16, students use what they know about energy to design their Rube Goldberg machines (pages 101–102).
- *Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.*
  - Claimed for Lesson 4.3.
    - In Steps #17–20, students are asked to think about what data they have to support the claim "objects that moved faster had more energy and went farther" (page 49).
    - In Step #33, students use the data from their investigation to "describe in their science notebook what they now think about the relationship of the moving object to how much energy it possesses and how energy can be moved from place to place by moving objects" (page 51).
  - Claimed for Lesson 4.4. In Step #3, students work as a class to collaboratively write a claim about how energy is transferred based on what they know so far (page 73).
  - Claimed for Lesson 4.5. Students use part of this element. In Steps #10–16, students use their observations from previous Rube Goldberg machines to design their own Rube Goldberg machine that will solve their problem (pages 101–102).
- *Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.*
  - Part of this element is claimed for Lesson 5: *~~Generate~~ and compare ~~multiple~~ solutions to a problem based on how well they meet the criteria and constraints of the design solution*. In Steps 17–19, students compare their designs with other groups and discuss if the design met the criteria and constraints, how effective it is, and what they might consider changing before the next testing (page 102).
- *Construct an explanation of observed relationships ~~(e.g., the distribution of plants in the backyard).~~*

- Claimed for Lesson 4.4. In Step #3, students work as a class to collaboratively write a claim about how energy is transferred based on what they know so far (page 73). Students may be using the relationships they observed in the previous investigations.

Engaging in Argument from Evidence

- *Compare and refine arguments based on an evaluation of the evidence presented.*
    - Claimed for Lesson 4.4. In Step #31, student groups share their claims and evidence, and other groups are asked to evaluate the evidence by considering the following questions "How strong do they think the reporting group's evidence is to support the claim? What could be done to make it stronger?" (page 79).
- *Construct and/or support an argument with evidence, data, and/or a model.*
    - Claimed for Lesson 4.4. In Steps #29–32, students use the evidence from their investigations to make a claim about energy transformations (page 79). They are asked to include the evidence that supports the claim.

Obtaining, Evaluating, and Communicating Information

- *Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.*
    - Claimed for Lesson 4.4. Students only use small pieces of this element. In Steps #30–32, they are asked to write their claim about energy transformations on a poster and then share it verbally (page 79).
    - This element is not claimed for Lesson 4.5, but in Steps #28–30, students engage with parts of this element use the provided energy cards to help them explain the transfer or transformation of energy (pages 102–103).

Disciplinary Core Ideas (DCIs) | **Rating: Adequate**

The reviewers found adequate evidence that students have the opportunity to use or develop the DCIs in this unit. Students have opportunities to develop and use many DCI elements, but not all of the elements that are claimed for each lesson.

PS3.A Definitions of Energy

- *The faster a given object is moving the more energy it possesses.*
    - Claimed for Lesson 4.3.
        - In Steps #3–6, students explore how marbles, dominoes, ramps, and blocks interact, and are asked to discuss the patterns that they notice (page 46). Then, the students share their observations and are asked to make a statement about what they think is the relationship between speed and energy. If students provide the response that is expected, they will be engaging with this claimed element.
        - The focus of the first investigation students plan in Part III is the relationship between the speed of an object and the energy it possesses, so students have

an opportunity to build an understanding of this element through this investigation. Students' investigations look at how the height of a ramp chances the speed of a ball. This may also begin laying the foundation for Middle School energy concepts.

- *Energy can be moved from place to place by moving objects or through sound, light, or electrical currents.*
    - Claimed for Lesson 4.1. The teacher leads a discussion about energy, and students are asked to share their ideas about energy and chart them (page 23). In this lesson the teacher only elicits what students already may know about energy, so students do not have opportunities to develop a new understanding of this element.
    - Part of this element is claimed for Lesson 4.2. *Energy can be moved from place to place by moving objects ~~or through sound, light, or electrical currents.~~*
        - In Steps #19–21, students create a model to show how *Audri's Rube Goldberg* operates, and they are asked to think about where the energy came from, what it did and where it went (pages 34–35). However, it is unclear where students will have gotten the understanding to be able to use this DCI in their responses, as there is only a brief conversation about energy in Step #18. It is unclear that they will have prior knowledge of this element, since it is not introduced in the K–2 grade band.
        - In Steps #24–25, students re-watch the Tom and Jerry video from Lesson 1 and identify observable changes in the system that provides evidence that energy is present (page 35). Students are given an exit slip with the prompts: "how do we know energy transferred in the system? Where does the energy come from? Where does the energy go?" However, it is unclear where students will have gotten the understanding to be able to use this DCI in their responses, as there is only a brief conversation about energy in Step #18.
    - Claimed for Lesson 4.5. Students use some of this understanding when they design and build their Rube Goldberg machines in steps #10–16 (pages 101–102).

PS3.B Conservation of Energy and Energy Transfer

- *Moving objects contain energy. The faster the object moves, the more energy it has. Energy can be moved from place to place by moving objects, ~~or through sound, light, or electrical currents~~. Energy can be converted from one form to another form.*
    - This is claimed as a learning target for the unit, but this is not an actual NGSS DCI element. The only time this is claimed for a lesson is for the optional formative assessment lesson 4.3a.
- *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.*
    - Claimed for Lesson 4.1. The teacher leads a discussion about energy, and students are asked to share their ideas about energy and chart them (page 23). In this lesson the teacher only elicits what students already may know about energy, so students do not have opportunities to develop an understanding of this element.

  - Claimed for Lesson 4.2. In Step #18, students build an understanding of a piece of this element, when they are told that "scientists use the word energy whenever this is motion" (page 34).
  - Part of the element is claimed for Lesson 4.3. *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 the Elaborate section, students conduct an investigation in which they see what happens to a stationary object at the bottom of a ramp when they release a moving object (pages 50–51). In Steps #26, students are expected to observe that "the car coming down the ramp had energy. It hit the car at the bottom transferring some energy to make it move. The original car stopped, so it must have lost some energy" (page 51). In Steps #29–30, students continue building an understanding as they discuss the collisions they observed and make pictorial representations of their discussions.
  - Claimed for Lesson 4.4. Students may continue to build an understanding of the first part of this element as they work through the four energy transformation stations in Steps #12–13.
- *Energy can also be transferred from place to place by electrical currents which can then be used to locally produce motion, sound, heat or light.*
  - Claimed for Lesson 4.1. The teacher leads a discussion about energy, and students are asked to share their ideas about energy and chart them (page 23). In this lesson the teacher only elicits what students already may know about energy, so students do not have opportunities to develop an understanding of this element.
  - Claimed for Lesson 4.4. Students build an understanding of this element as they work through the four energy transformation stations in Steps #12–13.

PS3.C Relationship Between Energy and Forces

- *When objects collide, the contact forces transfer energy so as to change the objects' motion.*
  - Claimed for Lesson 4.1. The teacher leads a discussion about energy, and students are asked to share their ideas about energy and chart them (page 23). In this lesson the teacher only elicits what students already may know about energy, so students do not have opportunities to develop an understanding of this element.
  - Claimed for Lesson 4.2, but no evidence was found. In this lesson, students only build an understanding that "scientists use the word energy whenever this is motion" (page 34).

PS3.D Energy in Chemical Processes and Everyday Life

- *The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use.*
  - Claimed for Lesson 4.5, but no evidence was found of student use or development of the element.
  - This element is not claimed for Lesson 4.4, but if students make a Lemon Battery in #25b, they will engage with this element (page 78).

ETS1.A Defining and Delimiting Engineering Problems

- *Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria).*
    - Claimed for Lesson 4.5. In Step #9, students work as a class to discuss the criteria and constraints for their design (page 100). The *4.5.C1: Criteria and Constraints* handout is provided as a reference to help guide the discussion, if needed (page 101).

Crosscutting Concepts (CCCs) | **Rating: Adequate**

The reviewers found adequate evidence that students have the opportunity to use or develop CCCs in this unit. Students have opportunities to develop and use many CCC elements, but not all of the elements that are claimed for each lesson.

Patterns

- *Similarities and differences in patterns can be used to sort, classify, communicate, and ~~analyze simple rates of change~~ for natural phenomena and designed products.*
    - Claimed for Lesson 4.2 (the full element). In Step #14, students are asked to write cause-and-effect statements that explain the sequence of the Rube Goldberg machine (page 33). Then in Step #15, student groups alternate sharing out their cause-and-effect statements for the failed tries vs. the successful tries (page 34). In Step #16, the teacher debriefs what they noticed about patterns in both situations. Students most likely look at the similarities and differences in the patterns (developing an understanding of the first part of the element).

Cause and Effect

- *Cause and effect relationships are routinely identified, tested, and used to explain change.*
    - Claimed for Lesson 4.1. Students begin to build an understanding of this element by identifying cause-and-effect relationships. After students watch the Tom and Jerry cartoon, they are told to share their observations with a group by "stating what they observed happening and what caused it" (page 21). The teacher continues to lead the discussion in which students share their observations and share how the actions represent cause-and-effect relationships (pages 21–22).
    - Claimed for Lesson 4.2
        - In Step #4, students use cause-and-effect statements to identify the sequence of events in *Audri's Rube Goldberg Monster Trap* video (page 31).
        - In Step #14, students write cause-and-effect statements that explain the sequence of the Rube Goldberg machine (page 33).
    - Claimed for Lesson 4.3. In Step #32, students are asked to think about how the cause-and-effect relationship helped them explain their prediction (page 51).
    - Claimed for Lesson 4.4

        - Students most likely observe and identify cause-and-effect relationships as they rotate through the four energy transformation stations in Steps #12–13 (pages 74–76).
        - In Step #21, students are given sentence frames in the *4.4C1: Sentence Frames for Analyzing Our Data: Station 1* handout which has them identify cause-and-effect relationships.
    - Claimed for Lesson 4.5. Students use some of this understanding when they design and build their Rube Goldberg machines in steps #10–16 (pages 101–102).

System and System Models

- *A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.*
    - Claimed for Lesson 4.2. In Step #11, students are asked whether they think the sections of the Rube Goldberg machine match their understanding of what a system is (page 32). Groups share their ideas, and a class definition of what a system is, is created. The expected student response is "a group of related parts that make up a whole; the whole does more than the individual parts can do; if there is a change in a part, it can impact the whole." A *Teacher Note* states what previous experience students may have to this systems CCC element and suggests how to make connections to students' previous experiences (page 33). In Step #12, students discuss why looking at a system might help them understand why the Rube Goldberg machine worked in some parts but not as a whole (page 33).
    - Claimed for Lesson 4.5. Students may implicitly use some of this understanding when they design and build their Rube Goldberg machines in steps #10–16 (pages 101–102).
- *A system can be described in terms of its components and their interactions.*
    - Claimed for Lesson 4.2. In Step #12, students discuss why looking at a system might help them understand why the Rube Goldberg machine worked in some parts but not as a whole (page 33). Students may be using an understanding of this element during this discussion, there is no evidence that students are aware that they are engaging with this element.
    - Claimed for Lesson 4.3. The only time students are asked to think about what they are working with as a system in the lesson is in Step #23 when they are told to use their previous claim "to generate testable questions about this system of objects." Students most likely will not develop or use this CCC.
    - Claimed for Lesson 4.4. There is no evidence that students explicitly develop or use this element.
    - Claimed for Lesson 4.5. Students may implicitly use some of this understanding when they design and build their Rube Goldberg machines in steps #10–16 (pages 101–102).

Energy and Matter

- *Energy can be transferred in various ways and between objects.*
  - Claimed for Lesson 4.1. The idea of energy is introduced in this lesson to surface student understanding of energy so far and there is no evidence that students use this element.
  - Claimed for Lesson 4.2. In Steps #24–25, students re-watch the Tom and Jerry video from Lesson 1 and identify observable changes in the system that provides evidence that energy is present (page 35). Students are given an exit slip with the prompts: "how do we know energy transferred in the system? Where does the energy come from? Where does the energy go?" Expected student answers include the idea that energy is transferred. However, due to the overlap between the target DCIs and this element, it is unclear if students build an understanding of energy as a CCC.
  - Claimed for Lesson 4.3. In the Elaborate section, students conduct an investigation in which they see what happens to a stationary object at the bottom of a ramp when they release a moving object (pages 50–51). In Steps #26, students are expected to observe that "the car coming down the ramp had energy. It hit the car at the bottom transferring some energy to make it move. The original car stopped, so it must have lost some energy" (page 51). In Steps #29–30, students continue building an understanding as they discuss the collisions they observed make pictorial representations of their discussions. Due to the overlap between the target DCIs and this element, it is unclear if students build an understanding of energy as a CCC.
  - Claimed for Lesson 4.4. Students build an understanding of the idea that energy can be transferred as they work through the four energy transformation stations in Steps #12–13. Due to the overlap between the target DCIs and this element, it is unclear if students build an understanding of energy as a CCC.
  - Claimed for Lesson 4.5. Due to the overlap between the target DCIs and this element, it is unclear if students build an understanding of energy as a CCC.
- *Matter is made of particles.*
  - This element is claimed in the Appendix for Lesson 4.1 but is not claimed at the beginning of the unit with the rest of the elements). There is no evidence students engage with this element.

Suggestions for Improvement

Science and Engineering Practices

Consider removing or adjusting some of the claims in the lessons to strengthen the match between the claimed elements and what students use or develop in the lessons.

Disciplinary Core Ideas

Consider removing some of the DCI elements as learning targets in Lesson 4.1's Appendix to make the claims more accurate. Lesson 4.1 is more of an introductory lesson and it does not provide opportunities for students to build an understanding of the currently claimed DCI elements.

Crosscutting Concepts
Consider providing guidance to the teacher as to what they can look for to ensure that students are developing and using **Energy and Matter** as a CCC and not just as a DCI. Asking students to apply or connect what they are learning about how energy is transferred to understand different contexts can help them use it as a crosscutting concept.

I.C. INTEGRATING THE THREE DIMENSIONS

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

Rating for Criterion I.C. Integrating the Three Dimensions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena and/or designing solutions to problems. Students have several opportunities to engage in multi-dimensional learning in service of problem solving or sense making. Some examples include:

- In Lesson 4.2 Steps #19–20, students develop a model to show how *Audri's Rube Goldberg* operates (pages 34–35). They use a **Developing and Using Models** SEP along with some **PS3.A** DCI understanding. Although students are not explicitly asked to think about **Systems**, they may use some of that understanding from a conversation earlier in the unit. Students are in the process of solving a problem.
- In Lesson 4.3 Steps #19–20, students look for patterns in their data to see if there is evidence to support their claim (pages 49–50). They use a **Constructing Explanations and Designing Solutions** SEP along with an unclaimed **Patterns** CCC understanding and **PS3.A** DCI understanding. They eventually use this understanding to help them solve the stalled Rube Goldberg machine.
- In Lesson 4.4 Steps #29–32, students use the evidence from their investigations to make a claim about energy transformations (page 79). Students use an **Engaging in Argument from Evidence** SEP along with **PS3.B** DCI understanding and most likely some **Cause and Effect** CCC understanding. Students then discuss how their claim and evidence statements can help them explain the flow of energy in the Rube Goldberg machine.
- In Lesson 4.5 Steps #10–16, students design and build their Rube Goldberg machines to solve a problem (pages 101–102). Students use a **Constructing Explanations and Designing Solutions** SEP along with **Cause and Effect** CCC understanding and **PS3.A** DCI understanding in service of problem solving.

- In Lesson 4.5 Step #11, students design their Rube Goldberg machines (page 101). Students use a **Developing and Using Models** SEP along with **PS3.A and PS3.B** DCI understanding in service of problem solving. They also most likely implicitly use some **Systems** CCC understanding.

Suggestions for Improvement

N/A

I.D. UNIT COHERENCE

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.

Rating for Criterion I.D. Unit Coherence	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that lessons fit together coherently to target a set of performance expectations because students see coherent links throughout most of the unit and have opportunities to revisit questions that they asked earlier in the unit. However, students do not have opportunities to build proficiency in all of the targeted PEs.

Related evidence includes:

- The *Procedure* box in Lesson 4.1 states that “at the end of the lesson, the class will create the **Our Thinking So Far** chart. This chart will be modified as students go through the learning sequence. In some cases, thinking will be revised, changed completely, or added to” (page 20). However, it is not clear exactly what thinking this chart tracks or what specific thinking students should be recording on it. Related evidence includes:
    - Lesson 4.1 Step #19 states: “have students share and add their input to *Our Thinking So Far* chart. Record how students are describing their observations based on their concepts about energy” (page 23). Based on the second sentence, it seems as if the teacher will be tracking students’ general thinking about energy, but this is unclear.
    - In Lesson 4.2 Step #23, the teacher adds to or refines student thinking (page 35).
    - In Lesson 4.3 Step #35, the teacher adds to or refines student thinking (page 51).
    - In Lesson 4.4 Step #28, the teacher adds to or refines student thinking (page 79).

- In the *Advance Preparation* section for Lesson 1, the teacher is told to prepare an "Our Questions" chart (page 19). Students have opportunities to review questions they have asked previously. Some examples include:
    - In Lesson 4.1 Steps #15–16, students are asked to think about questions they have about the mousetrap and the teacher charts their questions when they share as a class (page 22). The teacher is told to use the *Our Questions* chart to briefly discuss which student questions might lead to an investigation.
    - In Lesson 4.2 Step #1, the class reviews the questions from the *Our Questions* chart from Lesson 4.1 (page 31). The students are told they will have an opportunity to try to answer their questions.
    - In Lesson 4.2 Step #7, students return to the chart to record their additional questions (page 31).
    - In Lesson 4.3 Step #1, the teacher refers to the *Our Questions* chart and points out questions relevant to the lesson's focus (page 46).
    - In Lesson 4.5 Step #1, the teacher is told to review the *Our Questions* chart to look for anything related to how energy is transferred/transformed in our daily lives (page 99). Guidance is provided for what to do if there are no questions like these.
- Students revisit their models made in the unit. Some examples include:
    - In Lesson 4.2 Step #3, students review their models from Lesson 4.1 and discuss the patterns that they notice (page 31).
    - In Lesson 4.4 Step #7, students review their models from Lesson 4.2 (page 74).
- The topic of Rube Goldberg machines provides a thematic link across the unit so that students understand that what they are learning will be connected to explaining a type of Rube Goldberg machine. However, the sequence of the content in some lessons may not be fully coherent from a student's perspective. For example, Lesson 4.1 presents students with a scenario in which people need to get rid of mice in their pantry. Students are asked to think of criteria that would make a good mousetrap and then are shown a Tom and Jerry cartoon that shows an elaborate Rube Goldberg mousetrap. However, students never return to solving the problem presented to them at the beginning of the unit and are instead asked to think about energy transfers in the Tom and Jerry video and are then presented with different phenomena. This results in a potential loss of coherence from the students' perspective.

The unit helps students build proficiency in most of the targeted PEs. While students have opportunities to build proficiency in the targeted SEPs for each PE, they do not have opportunities to reach proficiency in all of the targeted DCIs and CCCs in each PE. The target PEs are listed as:

- 4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.
- 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- 4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.

- 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Suggestions for Improvement

- Providing students opportunities to build full proficiency in all of the claimed DCI and CCCs in the target PEs could strengthen the evidence for this criterion. Alternately, consider modifying the PE claims to clarify that students will only build partial proficiency during the unit.
- Consider sequencing the investigative phenomena and problems and the content in each lesson in a way that they build off of each other and make sense to the students. Allowing students to apply what they learn to fully address each scenario presented to them could help increase coherence.

I.E. MULTIPLE SCIENCE DOMAINS

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

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.

Rating for Criterion I.E. Multiple Science Domains	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that links are made across the science domains when appropriate because the phenomena and problems presented to students can be completed explained using the targeted disciplinary core ideas from the physical science domain. Additionally, the crosscutting concept elements are explicitly used in the unit to make connections between scientific domains (physical and life sciences).

Related evidence includes:

- The Rube Goldberg machine can be explained using grade appropriate elements from the physical science domain.
- Students are scaffolded in explicitly building an understanding of multiple CCC elements. In Lesson 4.2, the *Teacher Note* for Step #11, states that Systems and System Models is the focus CCC for Life Science in fourth grade and that “If you are teaching this learning sequence prior to a life science sequence, be sure to refer to this learning sequence so students can build on their understanding of system interactions when exploring systems in other science domains. In this

way they will see that the crosscutting concepts really do help in making meaning across all science domains. If students have already experienced a life science learning sequence and have explored interactions in systems from a life science context, be sure to make explicit connections to that learning" (page 33).

Suggestions for Improvement

Consider modifying the teacher suggestions about CCC connections if this learning sequence comes before a life science sequence in Grade 4. Teachers could be prompted to make connection back to other prior learning (e.g., from Grade 3) if a life science sequence comes later in Grade 4.

I.F. MATH AND ELA

Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects.

Rating for Criterion I.F. Math and ELA	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials provide grade-appropriate connections to the Common Core State Standards (CCSS) in mathematics, English language arts (ELA), history, social studies, or technical standards because CCSS standards are identified for every lesson, and there is evidence that students are engaging with those standards, although these connections are not made explicit to them.

CCSS standards are listed in the Appendix for each lesson. Some examples include:

- Lesson 1
    - *CCSS.ELA-LITERACY.W.4.8: Recall relevant information from experiences or gather relevant information from print and digital sources; take notes, paraphrase, and categorize information.*
        - In Step #8, students record actions that they agreed they observed using the sentence strips provided (page 21).
- Lesson 2
    - *CCSS.ELA-LITERACY.W.4.2: Write informative/explanatory text to examine a topic and convey ideas and information clearly.*
        - Students are asked to write and/or draw in their exit slips to respond to the questions about energy (page 35).

- Lesson 3
  - *CCSS.ELA-LITERACY.SL.1: Engage effectively in a range of collaborations.*
    - In Step #2, students work with partners to investigate patterns of movement and record their setups and their observations (page 46). Then, in Part III, students work with partners and as a class to plan an investigation (page 47).
  - *CCSS.ELA-LITERACY.SL.4: Report on a topic or text.*
    - In Steps #27–31, students make a pictorial representation of their observations and discussions and some groups are asked to share their representations (page 51).
  - *CCSS.ELA-LITERACY.SL.6: Differentiate between contexts that call for formal English and situations where informal discourse is appropriate.* No explicit evidence is found of student use or development of this standard.
  - *CCSS.ELA-LITERACY.W.8: Recall relevant information from experiences.* No explicit evidence is found of student use or development of this standard.
- Lesson 4
  - *CCSS.ELA-LITERACY.W.4.7: Conduct short research projects that build knowledge through investigation of different aspects of a topic.*
    - In this lesson students rotate through different stations making observations about energy, but they do not conduct research projects.
- Lesson 5
  - *CCSS.ELA-LITERACY.W.4.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.*
    - In Step #23, students are asked to write a paragraph to explain why their machine is effective and efficient in transferring energy to pass an eraser to another person (page 102).
  - *CCSS.ELA-LITERACY.W.4.8: Recall relevant information from experiences or gather relevant information from print and digital sources; take notes, paraphrase, and categorize information.*
    - In Step #12, students are "encourage to review their science notebook to look for scientific ideas and data to support their design ideas" so they may be recalling relevant information from their experiences in this unit (page 101).

Suggestions for Improvement

Consider making the connections to ELA standards explicit to students when they use them in the unit.

OVERALL CATEGORY I SCORE: **2** (0, 1, 2, 3)	
Unit Scoring Guide – Category I	
Criteria A-F	
3	At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C
2	At least some evidence for all unit criteria in Category I (A–F); adequate evidence for criteria A–C
1	Adequate evidence for some criteria in Category I, but inadequate/no evidence for at least one criterion A–C
0	Inadequate (or no) evidence to meet any criteria in Category I (A–F)

CATEGORY II

NGSS INSTRUCTIONAL SUPPORTS

II.A. RELEVANCE AND AUTHENTICITY

II.B. STUDENT IDEAS

II.C. BUILDING PROGRESSIONS

II.D. SCIENTIFIC ACCURACY

II.E. DIFFERENTIATED INSTRUCTION

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

II.A. RELEVANCE AND AUTHENTICITY

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

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.

Rating for Criterion II.A. Relevance and Authenticity	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world because students experience phenomena directly through media representations. However, limited connections to students' lives are made.

Multiple phenomena and problems are introduced to students in the unit. These are presented to students directly through videos so that all students have opportunities to experience them. For example, in Lesson 2 students watch *Audri's Rube Goldberg Monster Trap* video to experience the problem that part of the Rube Goldberg machine is not working as intended.

Limited guidance is provided for how the learning can directly connect to students' lives. Related evidence includes:

- A Teacher Note in Lesson 1 states that the lesson is about "increasing students' awareness of their own relevant ideas and experiences" (page 20). However, students are not explicitly asked to recall their own experiences and guidance to teachers for how to help students become aware of how their experiences and lives are connected to what they are exploring is not provided in the lesson.
- In Lesson 4.1 Step #1, students are presented with a scenario in which a mouse has eaten through a bag of chips. Although students are asked to think of what they might do to get rid of the mice, and it is likely that some students have prior experiences with this issue, students are not explicitly asked to recall and share any experiences with mice or animal traps.
- In Lesson 4.4 Step #8, students work in groups to generate examples of where energy is transformed in daily life (page 74).
- In Lesson 4.5 Step #1, the teacher reviews the *Our Questions* chart to identify student questions that have been previously raised regarding energy transformations in their daily lives (page 99). Students are asked if "they think that what they learned could be useful in the real world

outside of the classroom." In Step #2, students work with partners to write or draw three ways in which energy transfers or transformations are useful in their everyday life.

- In Lesson 4.5, students think about how they might design a device that converts energy for practical use in their classroom.

Suggestions for Improvement

- Consider providing students with opportunities to share their experiences related to the investigative phenomena and problems that they explore in the unit. For example, in Lesson 4.1 Step #1, students could be explicitly asked to share what they already know about mouse traps, where they may have seen them before, etc.
- The exit ticket for Lesson 4.3 asks students to respond to a prompt with fictional characters who want to make the Rube Goldberg successful. To make the problem solving more authentic, and to allow students to see how what they have learned is helping them solve the problem that was identified, consider modifying the prompt so that students are asked what *they* learned that could help make the machine successful.

II.B. STUDENT IDEAS

Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and respond to peer and teacher feedback orally and/or in written form as appropriate.

Rating for Criterion II.B. Student Ideas	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials provide students with opportunities to both share their ideas and thinking and respond to feedback on their ideas. Students have opportunities to express, clarify, and represent their ideas in the unit and to provide and respond to peer feedback. However, prompts for teacher feedback were not found.

Students have opportunities to express and share their ideas, and some of the artifacts produced include a mix of drawing and writing, and also include showing student reasoning. Some examples include:

- In Lesson 4.1 Step #2, students are asked to generate and share criteria that would make a good mousetrap (page 20). However, there is no evidence that all students would respond.
- In Lesson 4.1 Steps #4 and #6, students are to record their observations in their science notebook (pages 20–21).

- In Lesson 4.1 Steps #13–14, students work in groups to create a model of one section of the mouse trap, and them a few groups are selected to share their models with the class (page 22).
- In Lesson 4.2 Steps #4 and #9, students record the sequence they think is supposed to happen in the machine using cause and effect statements (pages 31–32).
- In Lesson 4.2 Steps #19–21, students work in groups to create a model to show how the machine operates and then the class compares some of the models to identify what is similar and different (page 34).
- In Lesson 4.2 Step #25, students are instructed to used words and pictures to respond to prompts as part of an Exit Ticket (page 35).
- In Lesson 4.3 Step #3, students record their observations and ideas in their science notebooks related to the investigations they conduct (page 46).
- In Lesson 4.3 Step #33, students respond in their notebooks what they think about the relationship between moving objects and the energy it possesses and how energy can be moved from place to place (page 51).
- In Lesson 4.3 Step #36, students individually complete an Exit ticket through written responses (page 52).
- In Lesson 4.4 Step #4, students share their observations in a think-pair-share and the teacher is provided with sentence frames to help students engage in conversations if needed (pages 73–74).
- In Lesson 4.5 Steps #10–11, students work with partners to discuss possible design ideas for their Rube Goldberg machines, and then they share their ideas with other groups (page 101).

Students have some opportunities to receive and respond to peer feedback. Students also have many opportunities to think through ideas and work in partners/groups, during which they may receive some unstructured feedback. Related evidence includes:

- In Lesson 4.1 Steps #10–11, students work in table groups to create sentence strips that illustrate the cause/effect relationships they observed in the Tom and Jerry video. Groups share these with the whole class “so that the class has a sense of how others viewed the actions” (page 21).
- In Lesson 4.2 Step #5, students work with partners to share ideas about the cause/effect statements they have created and the patterns they have observed (page 31).
- In Lesson 4.4 Steps #29–31, students work in groups to respond to the prompts in the Exit Slip (page 79). Some groups are selected to share their claim and evidence and other groups are asked to evaluate the evidence to see how strong the evidence is and what can be done to make it stronger.
- In Lesson 4.5 Steps #10–14, students work with partners to discuss possible design ideas for their Rube Goldberg machines. Then, students are asked to share their ideas, and groups are asked to compare the proposed solutions and modify their ideas based on class discussion (page 101).
- Lesson 4.5 Part IV, students discuss their designs with other groups and offer suggestions for improvements for their design (page 102).

Students may have some opportunities to receive teacher feedback, although the teacher is not explicitly instructed to provide the feedback to students and allow them time to reflect on it. Thus, these opportunities are not set up in a way that ensures all students will receive feedback. Some examples include:

- In Lesson 4.2 Step #25, students are asked to respond to prompts about energy using the Exit Strips strategy (page 35). Guidance for what the teacher should look for in answers is provided, but there is no guidance for how to use this information to respond to individual students.
- In Lesson 4.3 Step, #33, students are instructed to describe their thinking about moving objects and the amount of energy possessed in their science notebooks (page 51). Guidance as to what to look for in student responses or how to provide feedback is not provided.
- In Lesson 4.3 Step #37, students are instructed to complete an Exit Ticket (page 52). Teachers are guided to determine if students understand the three-dimensional learning for the lesson or if the students need additional support. Guidance as to what to look for in student responses or how to provide feedback is not provided.

Suggestions for Improvement

- Consider establishing a feedback cycle at several points in the unit through which students can receive and respond to teacher feedback.
- Consider structuring the peer and teacher feedback opportunities in a way that all students are guaranteed to receive constructive feedback and have explicit time set aside to reflect on and respond to the feedback.
- Consider modifications to the science notebook activities to prompt students to reference and revise their understandings as they compare them to their peers' ideas and the feedback they receive from their teachers.

II.C. BUILDING PROGRESSIONS

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.

Rating for Criterion II.C. Building Progressions	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials identify and build on students' prior learning in all three dimensions because prior student learning expected for the dimensions is identified in the materials and a learning progressions chart is included.

Related evidence includes:

- SEP, DCI, and CCC Progression Charts are provided (pages 11–14). These charts detail how students will be using a particular SEP, CCC, or DCI category in the lessons. However, the chart does not include the expected level of prior proficiency students should have for specific elements (versus categories, like "**Energy and Matter**") in all three dimensions.
    - Some, but not most, of the categories include a progression of how students will use the particular category. For example, the **Energy and Matter** table states that in Lesson 4.1 "students begin to recognize that energy transfer occurs in the Tom and Jerry cartoon" and that in Lesson 4.2 "Students continue to identify energy transfers in the Rube Goldberg machine."
    - Some, but not most, of the categories also describe how students will build on their K–2 prior learning. For example, the Asking Questions and Defining Problems table states that in Lesson 4.1 "Accessing prior knowledge from K–2 (ask questions based on observations to find more information about the natural world), students ask questions that can be answered by an investigation."
- The *Storyline Link* for Lesson 4.1 states that "students use their prior knowledge from kindergarten through grade 3 about force and motion to observe and describe chain reactions in terms of action (movement) and how the action occurred (forces)" (page 18).
- In Lesson 4.1 Step #12, students are asked to share how the order of actions represents cause and effect relationships (page 21). The *Teacher Note* tells the teacher to reflect on students' prior knowledge of cause-and-effect relationships from K–2.
- In Lesson 4.1 Step #16, the *Teacher Note* states that the teacher should reflect on students' prior knowledge of a K–2 grade band element of asking questions and then assess how students are thinking about questions that could lead to the target 3–5 grade band element (page 22).

- In Lesson 4.1 Step #19, the *Teacher Note* states to "take note of students' prior knowledge about the science and engineering practices and crosscutting concepts" (page 24).
- In the Appendix for Lesson 1, the DCI box states that "energy is not introduced until fourth grade, so this prior knowledge might be expressed from a students' life experiences or if they have already experienced other learning sequences in fourth grade that address energy DCIs" (page 25).
- In Lesson 4.2 Step #11, students are asked to think about whether they think the sections of the Rube Goldberg machine match their understanding of what a system is based on their prior knowledge (page 32). The *Teacher Note* states that students use prior knowledge from the K–2 grade band and also suggests how students can build on their understanding of systems depending on when this unit is taught (page 33).
- In Lesson 4.4, the *Teacher Note* in Step #3 provides guidance for how students will continue to build upon their understanding of energy transfer.
- In Lesson 4.5 Step #8, the *Teacher Note* states that students should have some experience with the engineering design process from previous problem solutions (page 100).
- In Lesson 4.3 Steps #20–22, students work in groups to write claims supported by evidence and then share as a class (page 50). The *Teacher Note* states that the purpose of the claim and evidence at this point is to help students understand "…raw data is not evidence; it has to be analyzed…"

Suggestions for Improvement

Consider explicitly identifying all of the performance expectations or the specific elements for all three dimensions that students need prior knowledge of before beginning this unit. These could be elements that students would need to know either from the K–2 grade band or from previous units in grades 3 and 4.

II.D. SCIENTIFIC ACCURACY

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

Rating for Criterion II.D. Scientific Accuracy	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials use scientifically accurate and grade appropriate scientific information. No inaccurate information was found in the unit, and a teacher note on page 73 describes possible student misconceptions about energy.

Suggestions for Improvement

N/A

II.E. DIFFERENTIATED INSTRUCTION

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.

Rating for Criterion II.E. Differentiated Instruction	Inadequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found inadequate evidence that the materials provide guidance for teachers to support differentiated instruction because there is limited evidence of strategies provided to explicitly support students who are struggling with the learning targets, read below the grade level, or are multilingual learners. Also, extensions for students who already met the learning targets are not provided.

Some options are provided that could help students who are struggling to meet the learning targets or are multilingual learners. However, these options are not explicitly identified as supporting any particular group. Some examples include:

- In Lesson 4.2 Step #25, students are asked to use "words and/or pictures" to answer the prompts (page 35).
- In Lesson 4.4, Step #4 includes sentence stems the teacher can use to help students engage in partner conversations (page 74).
- In Lesson 4.4, Step #29 includes sentence frames students can use to guide their conversations (page 79).
- Guidance is provided that lesson 4.3a is to be used, "if students need support to understand that observations can produce data as evidence, that within a system, moving objects contain energy, that the faster the object moves, the more energy it has, and that energy can be moved from place to place by moving objects."

Suggestions for Improvement

- Consider providing strategies that help students meet the targeted expectations for all three dimensions. Consider explicitly identifying these strategies with the group that they can help support.
- Consider offering extensions that help students build a deeper understanding of all three dimensions.

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

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.

Rating for Criterion II.F. Teacher Support for Unit Coherence	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials support teachers in facilitating coherent student learning experiences over time because teachers are provided with some guidance and routines that establish and reinforce coherence from a student's perspective.

In the *Advanced Preparation* section for Lesson 4.1, teachers are instructed to create the *Our Questions* chart, although guidance for creating it is not provided at this point (page 19). Guidance for how the chart will distinguish between and keep track of questions for different phenomena and problems is also not provided. However, teachers are provided with guidance of when to use and return to the chart consistently throughout the unit to identify which questions have been answered and to add new questions based on students' continued wonderings. Some examples include:

- In Lesson 4.1 Step #16, the teacher is told "using the *Our Questions* chart made in Advance Preparation, briefly discuss, using testable/non-testable criteria, which of the questions *might lead to an investigation* that would help students to understand their observations" (page 22). As this is the first mention of using the *Our Questions* chart, it can be assumed that the teacher at this point will be recording the questions that can lead to an investigation.
- In Lesson 4.2 Step #1, teachers are guided to have students return to the *Our Questions* chart they created in Lesson 4.1 (page 31). Guidance is provided to choose student questions related to real life examples of this type of "thing" and to use those to center the learning for the lesson.
- In Lesson 4.2 Step #7, teachers are directed to have students return to the *Our Questions* chart to record their additional questions and wonderings about the Rube Goldberg machine (page 31).
- In Lesson 4.2 Step #8, teachers are guided to identify questions about "Why did it work in some places and not in others?" and to use those questions to guide student discussions to compare and contrast patterns students have observed (page 32).
- In Lesson 4.2 Step #22, teachers are provided with guiding questions that can prompt students as they return to the *Our Questions* chart to record what they still want to know (page 35).
- In Lesson 4.3 Step #1, teachers are instructed to refer to the *Our Questions* chart and point out key questions such as, "What do we need to make the failed one work?, "If I make it go faster, could it work?, and How can I give it more energy so it will not stall?" Students are then asked to discuss answers to those questions to serve as the foundation for subsequent investigations (page 46).
- In Lesson 4.5 Step #1, teachers are guided to have students return to the *Our Questions* chart to identify questions related to energy transformations (page 99).

In the *Advanced Preparation* section for Lesson 4.1, teachers are instructed to create the *Our Thinking So Far chart* (page 19). Guidance for how to create the chart and what exactly students should contribute to the chart is not provided. However, teachers are provided with guidance of when to return to the chart consistently throughout the unit to capture how student thinking has changed. Some examples include:

- Lesson 4.1 Step #19 states: "have students share and add their input to *Our Thinking So Far* chart. Record how students are describing their observations based on their concepts about energy" (page 23). Based on the second sentence, it seems as if the teacher will be tracking students' general thinking about energy throughout the unit, but this is unclear.
- The teacher is guided return to chart to add to or refine student thinking in Lessons 4.2 (page 35), 4.3 (page 51), and 4.4 (page 79).

- In Lesson 4.5 Step #33, teachers are guided to have students return to the “Our Thinking” chart for a final time to make revisions.

Both the *Our Questions* and *Our Thinking So Far* charts seem to track questions and thinking for several different phenomena and problems introduced to students in the unit. Guidance for how students can see how their learning is helping them make progress toward explaining or solving a specific phenomenon or problem is not included.
The *Storyline Links* provided at the beginning of each lesson provide a brief overview of how the lesson fits into the unit.

Suggestions for Improvement

- Consider providing detailed guidance in how to set up the *Our Questions* and *Our Thinking So Far* charts. Including guidance for what exactly to track in the *Our Thinking So Far* charts and what should initially go into each chart could be helpful to the teacher.
- Consider providing some guidance and strategies for teachers to support students in seeing how their grade appropriate CCC and SEP learning contributes to problem solving.

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems.

Rating for Criterion II.G. Scaffolded Differentiation Over Time	Inadequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found inadequate evidence that the materials support teachers in helping students engage in the practices as needed and gradually adjust supports over time. Although students engage with several different SEP elements multiple times over the course of the unit, guidance or scaffolds are rarely adjusted over time to allow students to become increasingly responsible for figuring out the phenomena.

Related evidence includes:

- In Lessons 4.1, students are asked to create to “create a model of one section of the mousetrap that involves at least 3 changes” (page 22). Students are not given guidance as to how to build this model. Then in Lesson 4.2, students are asked to create a model just like they did in Lesson 4.1 to show how the machine operates (pages 34–35). This time, the teacher is instructed to ask students “what they might include in their model this time.” Additional support is added the second time students develop a model instead of the first time.

- In Lesson 4.3, students work as a class to plan an investigation and are asked how they should collect their data (page 47). Students conduct the investigation, collecting data and discussing their observations (page 49). The teacher then leads a class discussion to see “is the evidence that was used appropriate to support the claim? Why or why not? Was the evidence sufficient? Why or why not? What other evidence could be cited to make the claim stronger?” (page 50). The *Teacher Note* states that a purpose of this is to help students understand the difference between data and evidence. Then in Lesson 4.4, when students make observations and collect data again as they rotate through the four energy transformation stations (pages 82–85), the teacher is told to “conduct a brief conversation about the difference between data and evidence.” The *Teacher Note* states that “if your students are familiar with data and evidence this conversation should just be a review. If this is new to them, spend more time helping them see that raw data has little meaning…” (page 77). In Lesson 4.5, when students design their own Rube Goldberg machines to solve a problem, they are asked to look for scientific ideas and data to support their design ideas and the teacher is told to have “groups share their ideas and their data/evidence for those ideas” (page 101). This time, the teacher is not instructed to differentiate between data and evidence. This shows some scaffolding change for students in building an understanding of and using the basics behind the **Planning and Carrying Out Investigations** and **Analyzing and Interpreting Data** SEPs.

Suggestions for Improvement

- Consider modifying the support provided for developing a model in the unit so that students receive additional support earlier on in the unit, and then become increasingly more responsible for using modeling to solve problems and explain phenomena by the end of the unit.
- Consider providing students with multiple opportunities to engage in a SEP element throughout the unit, so that scaffolds for developing and using the SEP element can be adjusted and the teacher can clearly see the progress a student is making.

OVERALL CATEGORY II SCORE: **2** (0, 1, 2, 3)	
Unit Scoring Guide – Category II	
Criteria A-G	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least two criteria
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

CATEGORY III

MONITORING NGSS STUDENT PROGRESS

III.A. MONITORING 3D STUDENT PERFORMANCES

III.B. FORMATIVE

III.C. SCORING GUIDANCE

III.D. UNBIASED TASK/ITEMS

III.E. COHERENT ASSESSMENT SYSTEM

III.F. OPPORTUNITY TO LEARN

III.A. MONITORING 3D STUDENT PERFORMANCES

Elicits direct, observable evidence of three-dimensional learning; students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions.

Rating for Criterion III.A. Monitoring 3D Student Performances	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials elicit direct, observable evidence of students using practices with core ideas and crosscutting concepts to make sense of phenomena and design solutions. Students produce artifacts that require them to use more than one dimension in service of problem solving or sense making. However, not all targeted learning is monitored and most of the artifacts generated are from group activities without any guidance for how the teacher can monitor individual progress.

Some evidence includes:

- In Lesson 4.2 Steps #19–20, students develop a model in a group to show how *Audri's Rube Goldberg* operates (pages 34–35). They use a **Developing and Using Models** SEP along with some **PS3.A** DCI understanding. While students are not explicitly asked to think about **Systems**, they may use some of that understanding from a conversation earlier in the unit. Students are in the process of solving a problem. Teachers are provided guidance that students may still be struggling with how energy works in relation to the contact forces.
- In Lesson 4.3 Steps #19–20, students work in groups to look for patterns in their data to see if there is evidence to support their claim (pages 49–50). They use a **Constructing Explanations and Designing Solutions** SEP along with an unclaimed **Patterns** CCC understanding and **PS3.A** DCI understanding. They will eventually use this understanding to help them solve the stalled Rube Goldberg machine. Teacher questioning in steps 17–19 provides considerable scaffolding for this artifact.
- In Lesson 4.3 Step #33, students use the data from their investigation to "describe in their science notebook what they now think about the relationship of the moving object to how much energy it possesses and how energy can be moved from place to place by moving objects" (page 51). This shows evidence of student understanding of **Constructing Explanations and Designing Solutions** along with the **PS3.B** DCI elements, although students do not use these elements in service of sense-making or problem solving.
- In Lesson 4.3 Step #37, students complete the Exit Ticket individually using evidence from the previous activities contained with the lesson. While expected student results indicate that students primarily show an understanding of the DCI, there is a possibility that they could record their interactions with the other dimensions they have engaged with (**Planning and Carrying Out Investigations**, **Cause and Effect**, and **Patterns**).

- In Lesson 4.4 Steps #29–32, students work in groups to use the evidence from their investigations to make a claim about energy transformations (page 79). Students use an **Engaging in Argument from Evidence** SEP along with **PS3.B** DCI understanding and most likely some **Cause and Effect** CCC understanding. Students then discuss how their claim and evidence statements can help them explain the flow of energy in the Rube Goldberg machine.
- In Lesson 4.5 Steps #10–16, students design and build their Rube Goldberg machines to solve a problem (pages 101–102). Students use a **Constructing Explanations and Designing Solutions** SEP along with **Cause and Effect** CCC understanding and **PS3.A** DCI understanding in service of problem solving. Students engage in discussions with a group and build their machine in groups according to their design plan.
- In Lesson 4.5 Step #11, students design their Rube Goldberg machines (page 101). Students use a **Developing and Using Models** SEP along with **PS3.A and PS3.B** DCI understanding in service of problem solving. They also most likely implicitly use some **Systems** CCC understanding. Students generate a drawing of their design idea in groups.

Suggestions for Improvement

- Consider adding in opportunities through which students can show an understanding of all of the targeted learning.
- Consider providing some guidance for how the teacher can monitor students' individual progress when producing group artifacts.

III.B. FORMATIVE

Embeds formative assessment processes throughout that evaluate student learning to inform instruction.

Rating for Criterion III.B. Formative	Inadequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found inadequate evidence that the materials embed formative assessment processes throughout that evaluate student learning and inform instruction. Although formative assessment opportunities are identified, guidance for what to look for in student responses or how to modify instruction is not always provided.

Flag icons are used in the unit to "denote formative assessment opportunities where you may change instruction in response to students' level of understanding and making sense of phenomena" (page 18). Some examples of where flags appear in the unit are:

- Lesson 4.1 Step #5 notes that this question is a "pre-assessment of using criteria to solve problems" (page 21). Expected student responses (ESRs) are provided, but guidance for how to alter instruction is not provided.
- Lesson 4.1 Step #13 has a *Teacher Note* that lists very basic ideas of what teachers should look for in student models, but guidance for how to alter instruction is not provided (page 22).
- Lesson 4.2 Steps #24–26 ask students to complete an exit ticket and the *Teacher Note* instructs the teacher to "review the exit slips to determine if students understood the targeted three dimensions of the lesson or if they need additional support or review" (page 35). While ESRs are provided, guidance as to what to look for specifically for progress in each dimension or how to alter instruction is not provided.
- In Lesson 4.3 Step #33, the *Teacher Note* indicates that the student responses in their science notebooks can be used as a formative assessment (page 50). However, there is no guidance provided for expected student responses or for how instruction could be modified based on those responses.
- Lesson 4.3 Steps #36–37 has students complete an exit ticket (page 51). While ESRs are provided, guidance as to what to look for specifically for progress in each dimension or how to alter instruction is not provided. The exit ticket also only assesses DCI understanding.
- Lesson 4.3a is included as an "optional assessment if students need support to understand that observations can produce data as evidence, that within a system, moving objects contain energy, that the faster the object moves, the more energy it has, and that energy can be moved from place to place by moving objects" (page 60). The teacher is told to use "Steps 15 and 16 to see if students better understand the learning goals." However, there is no guidance provided to help teachers discern why they should choose this lesson as an alternative (i.e., how to know if students need extra support) or what teachers should look for to determine if the learning goals are met.
- Lesson 4.4, Step #32 asks students to rewatch the *3M Rube Goldberg Machine* video and discuss how their claim and evidence statements can help them explain the flow of energy (pages 79–80). While ESRs are provided, guidance for how to alter instruction is not provided. The exit ticket also only assesses DCI understanding.
- Lesson 4.5 Step #23 asks students to write a paragraph, using evidence, to explain why their machine is effective and efficient in transferring energy to pass an eraser to another person (page 102). In Step #24, the teacher is told to collect student paragraphs as a formative assessment of their understanding. The *Teacher Note* states that "This evaluation serves as an assessment/summary of what students understand about energy transfers. It addresses many of the three dimensions in this learning sequence" (page 103). However, expected student answers, guidance as to what to look for specifically for progress in each dimension, or guidance how to alter instruction are not provided.

Suggestions for Improvement

- For each formative assessment opportunity, consider identifying what the targeted element is for each dimension being assessed.

- Consider adding in support for how teachers could modify instruction based on student responses. Providing sample student responses for activity and checkpoint documents along with supports for how to tailor instruction based on what responses are received could strengthen the evidence for this criterion.
- Consider providing additional guidance to teachers and students about how to address gaps and misconceptions.

III.C. SCORING GUIDANCE

Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.

Rating for Criterion III.C. Scoring Guidance	Inadequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found inadequate evidence that the materials include aligned rubrics and scoring guidelines that help the teacher interpret student performance for all three dimensions. While expected student answers are included, scoring guidance for tasks is not provided to teachers on how to interpret and monitor student progress.

Related evidence includes:

- Expected student responses are included for most of the questions students are asked throughout the unit. They appear in italics after the question posed to the student.
- Scoring guides that identify the assessment targets, provide guidance for how to interpret student progress for the three dimensions, and that provide guidance to enable teachers to modify instruction are not included for the tasks in the unit.
- Examples of student models are not provided.

Suggestions for Improvement

- Consider providing scoring guidelines for a range of student responses for all three dimensions that show teachers how they can interpret student progress. For example, including descriptions for what a developing vs. proficient vs. advanced level of performance looks like for all three of the targeted dimensions integrated could help support the teacher in understanding and interpreting student responses.
- Example student models would be very helpful to include. These could show teachers what level and sophistication of models students are expected to produce at this grade level and how their models should change as they become more proficient with all three dimensions.

- Consider providing clearly stated assessment targets, for all dimensions being assessed and their use together, to ensure teachers can accurately interpret student performance along each dimension.

III.D. UNBIASED TASK/ITEMS

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

Rating for Criterion III.D. Unbiased Task/Items	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples. However, students do not have a choice of modality for their assessment responses.

Related evidence includes:

- Students are all shown videos of the Rube Goldberg machines and are provided with ample discussions and time to figure out what is going on.
- Students are given an appropriate amount of text in their tasks and the items are grade appropriate.
- Students are not expected to immediately know the term “energy” until they have a context for understanding it.
- Tasks do not provide students with a choice of responses across multiple modalities.

Suggestions for Improvement

Consider proving students with a choice of responses, across multiple modalities, in at least one major assessment task.

III.E. COHERENT ASSESSMENT SYSTEM

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

Rating for Criterion III.E. Coherent Assessment System	Inadequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found inadequate evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning because only formative assessment opportunities are provided in the unit. Pre-assessment, summative assessment, and self-assessment measures are not included.

Pre-assessment

- In Lesson 4.1 Step #5, a note states that this step is a "pre-assessment of using criteria to solve problems." However, this step does not assess DCI or CCC understanding.

Self-Assessment

- There are no explicit self-assessments identified in the unit.
- There are multiple peer interactions that could possibly serve as self-assessments if guidance were provided.

Formative Assessment

- While some formative assessment opportunities are identified, guidance for what to look for in student responses to see progress in all three dimensions or how to modify instruction is not always provided.
- See evidence in III.B

Summative Assessment

- No formal or informal summative assessment opportunities are provided in the learning sequence.
- Scoring guides are not provided to assess student understanding.

Suggestions for Improvement

- For self-assessment, consider providing additional guidance to students about how to monitor their own progress toward proficiency in each of the targeted three dimensions instead of only in cognitive skills.
- For formative assessments, see suggestions in III.B.

III.F. OPPORTUNITY TO LEARN

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

Rating for Criterion III.F. Opportunity to Learn	Inadequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found inadequate evidence that the materials provide multiple opportunities for students to demonstrate performance of practices connected with their understanding of core ideas and crosscutting concepts. Although there are multiple opportunities for students to show most of the claimed learning goals, there are minimal peer or teacher feedback loops present through which students receive feedback and are prompted to reflect on that learning and reapply their understandings for growth.

Related evidence includes:

- There are limited prompts and supports for teacher feedback during the unit. See evidence in II.B. This results in few opportunities for feedback loops through which students can improve their performance.
- In Lesson 4.5 Steps #10–14, students work with partners to discuss possible design ideas for their Rube Goldberg machines. Then, students are asked to share their ideas, and groups are asked to compare the proposed solutions and modify their ideas based on peer feedback from the class discussion (page 101).
- The *Our Thinking So Far* chart could provide an iterative opportunity for students to demonstrate how their thinking has changed over time. However, the charts are always revised as a whole class, so documentation of individual student thinking is not captured.
- The use of models to explain what is happening in the Rube Goldberg mousetrap and machine in Lessons 4.1 and 4.2 could potentially be used as iterative opportunities to show student growth. However, there are no specific teacher or peer feedback opportunities that could be used to motivate growth from one lesson to the next.

Suggestions for Improvement

- Consider establishing a feedback cycle at several points in the unit through which students can receive and respond to teacher and peer feedback.
- Consider providing additional opportunities for students to show their new thinking as a response to feedback they have received from their teachers or peers.

Chain Reaction

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL CATEGORY III SCORE: **0** (0, 1, 2, 3)	
Unit Scoring Guide – Category III	
Criteria A-F	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

SCORING GUIDES FOR EACH CATEGORY

UNIT SCORING GUIDE – CATEGORY I (CRITERIA A-F)

UNIT SCORING GUIDE – CATEGORY II (CRITERIA A-G)

UNIT SCORING GUIDE – CATEGORY III (CRITERIA A-F)

OVERALL SCORING GUIDE

Scoring Guides for Each Category

Unit Scoring Guide – Category I (Criteria A-F)	
3	At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C
2	At least some evidence for all unit criteria in Category I (A–F); adequate evidence for criteria A–C
1	Adequate evidence for some criteria in Category I, but inadequate/no evidence for at least one criterion A–C
0	Inadequate (or no) evidence to meet any criteria in Category I (A–F)

Unit Scoring Guide – Category II (Criteria A-G)	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least two criteria
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

Unit Scoring Guide – Category III (Criteria A-F)	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

Chain Reaction

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL SCORING GUIDE	
E	**Example of high quality NGSS design—**High quality design for the NGSS across all three categories of the rubric; a lesson or unit with this rating will still need adjustments for a specific classroom, but the support is there to make this possible; exemplifies most criteria across Categories I, II, & III of the rubric. (total score ~8–9)
E/I	**Example of high quality NGSS design if Improved—**Adequate design for the NGSS, but would benefit from some improvement in one or more categories; most criteria have at least adequate evidence (total score ~6–7)
R	**Revision needed—**Partially designed for the NGSS, but needs significant revision in one or more categories (total ~3–5)
N	**Not ready to review**—Not designed for the NGSS; does not meet criteria (total 0–2)