Light and Matter: Why Do We Sometimes See Different Things When Looking at the Same Object?

DEVELOPER: OpenSciEd

GRADE: Middle School | **DATE OF REVIEW:** October 2020

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Educators Evaluating Quality Instructional Products

NextGen Science
WestEd

Light and Matter: Why Do We Sometimes See Different Things When Looking at the Same Object?

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL RATING: E

TOTAL SCORE: 8

CATEGORY I: NGSS 3D Design Score	CATEGORY II: NGSS Instructional Supports Score	CATEGORY III: Monitoring NGSS Student Progress Score
2	3	3

Click here to see the scoring guidelines.

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

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

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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. This unit is strong in several areas, including:

- Explaining Phenomena/Designing Solutions — The unit is coherently designed such that the unit will support students in developing and using the three dimensions to make sense of an anchor phenomenon.
- Building Progressions — The unit builds on students' prior learning in all three dimensions at the middle school level with suggestions for adaptations if students are above or below that level.
- Scientific Accuracy — the unit uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning.

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

- Consider supporting student use or building of grade-appropriate CCC elements throughout the unit in order to achieve full three-dimensional integration and improving the coherence of the assessment system.
- Consider using student questions to drive subsequent lessons, perhaps taken from the DQB.
- Consider supporting use of grade-appropriate mathematics concepts during investigations where students generate data and lessons where students analyze data and graphs that are given to them, along with teacher support to help students make these connections between science and mathematics.
- Consider including more opportunities for individual or small group differentiation. The modalities could be more varied and different ways to explain ideas and phenomena could be offered in place of modeling, which is frequently utilized.
- Consider increasing the opportunities for students to sense-make individually and to show their thinking in an observable way to help improve monitoring of three-dimensional student performance.
- Consider including examples of different student responses to the assessments, such as from struggling students, students meeting the targets, and students performing beyond the expected level. In addition, consider including supports for how to respond to these different responses and providing more structured formative assessments earlier in the unit that allow the teacher to view all students' thinking and to provide feedback to all individual students.
- Consider providing more opportunities for students to give and receive feedback throughout the unit.

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.

Also note that the Mr. Bean clip referenced in the review has been replaced with a new video clip, the Music Lesson, in the current version of the materials. References in the report to Mr. Bean and the people/men now refer to "music student" and the "people/adults" in the unit materials.

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

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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	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that learning is driven by students making sense of phenomena or designing solutions to a problem because students engage in a series of lessons in order to make sense of the anchoring phenomenon: one-way mirror. In doing so, they also explore a number of lesson-level driving questions related to phenomena such as:

- How can something act like a mirror and a window at the same time?
- What happens if we change the light?
- What happens when light shines on a one-way mirror?
- How does the one-way mirror transmit and reflect the same amount of light it shines on?
- How do light and the one-way mirror interact to cause the one-way mirror phenomenon?
- Why does the Rockstar student not see the parent/teacher?
- Why does the Rockstar student see him/herself but not the parent/teacher?
- Why do we sometimes see different things when looking at the same object?

This anchoring phenomenon is rich enough to drive the learning throughout the unit and elicit a range of investigable questions related to phenomena over the course of the unit. Students regularly return to the phenomenon to add layers of explanation based on learning, or regularly build on what they have learned from smaller phenomena or problems to explain a broader science topic.

Student learning is focused on supporting students to better make sense of the phenomenon. For example:

- In Lesson 2, the students use a one-way mirror in and out of the box model and a flashlight to simulate the phenomenon video.
- In Lesson 3, the students use a light meter to better understand the way light behaves when it interacts with different materials.

- In Lesson 6, the students conduct an experiment using a magnifying glass and a flashlight to show how light interacts with a lens to simulate how light interacts with a human eye to explain how the Mr. Bean can see him/herself but not the parent/teacher.
- In Lesson 8, students investigate how glass can function as a one-way mirror if the amount of light is adjusted.

Students regularly return to the phenomenon to add layers of explanation based on learning, or regularly build on what they have learned from smaller phenomena to explain a broader science topic. For example:

- Lesson 1— Students develop their own initial model by drawing a first draft representation of what they think is causing the Rockstar student to see him/herself and not the teacher and the parent. They then compare their models with others and develop a Class Consensus Model, which combines an overall class interpretation of what happened in this phenomenon. Students return to this class model throughout the unit to update their understanding of the phenomenon (Lessons 2–8).
- Lesson 2 — Students create their own chart (Progress Tracker) in their science notebooks to record what they figured out from this lesson (and add to it as the unit continues). Students return to this chart at the end of every lesson to help them recognize what they learned and what investigations and phenomena they will need to make sense of in the next lesson to better understand the anchor phenomenon (Lessons 3–8).
- Lesson 2 — Students create a class Science Ideas Chart as a running record of the ideas the class agrees upon based on the findings/investigations they have done in class. They return to this chart in Lessons 6 and 7 to reinforce the scientific principles they have discovered during investigations in Lessons 3–5.

All of the student learning across the three dimensions targeted by the unit is in service of students making sense of phenomena or designing solutions to a problem. In several lessons, students investigate the underlying scientific concept (DCI: PS4.B) through reasoning about the evidence they observe during investigations (SEP). As students ask questions and develop models (SEP), they are continuously revisiting the crosscutting concepts (CCC) of systems and system models as well as structure and function. For example:

- Lessons 1 and 3 — Students ask questions to investigate the one-way mirror phenomenon.
- Lessons 1–8 — Students develop models to clarify their understanding about the one-way mirror phenomenon. With each lesson, their models are updated to showcase new information learned.
- Lessons 1–8 — Students explore the interactions between systems in order to explain the one-way mirror phenomenon. Each lesson features a deeper investigation of how materials of systems (light, one-way mirror, eye, glass) work together in order to produce the phenomenon the students are observing.
- Lessons 2, 4, 6, and 8 — Students analyze the structure of certain materials and how that may or may not affect its function to produce the phenomenon.

Student questions or prior experiences with the phenomena create a need for the students to engage throughout the materials. Materials provide structured support for teachers to draw out these connections from students and use these connections to motivate student learning. For example:

- Lesson 1 — Students create a Notice and Wonder chart to record their initial ideas about the phenomenon. These ideas help students work through their thinking about what happened to cause the phenomenon to occur and they help students to contribute to an anchor chart containing the possible causes of the phenomenon and what they are wondering about the phenomenon.
- Lesson 1 — Students create a Related Phenomenon chart where they record examples of when they've seen a phenomenon like the video. They return to this chart in Lesson 4 and Lesson 6 where they use everyday experiences to make sense of the one-way mirror phenomenon.
- Lesson 1 — Students develop a Driving Question Board based on their Notice and Wonder chart and their Related Phenomenon chart. They frequently revisit the questions to connect what students now know and the ideas that still need to be figured out. This helps students drive the learning and remain motivated throughout the unit.
- The anchoring phenomenon is revisited throughout the unit and the learning in each lesson is in service of figuring out the phenomenon. Starting in Lesson 2, the conclusion of each lesson features students using the Progress Tracker to record what they investigated and how it contributed to their understanding of the phenomenon.

Suggestions for Improvement

None

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. While students engage extensively with the DCI and SEP dimensions, they do not use grade appropriate CCCs in many lessons, and there is some mismatch between CCCs claimed and those used in the lessons.

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

The reviewers found extensive evidence that the materials provide opportunities to develop and use specific elements of the SEPs. Elements of the practice of **Asking Questions and Defining Problems** and **Developing and Using Models** are developed in the unit. In addition to this, elements of the practice of **Constructing Explanations and Designing Solutions** are used in some lessons. All of the activities are at the grade-appropriate level for a middle school/Grade 6 student and aid in student sense-making of the anchoring phenomenon. Below, several examples are listed:

Asking Questions and Defining Problems

- *Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.*
    - Lesson 1 — Students record their questions about the observed phenomenon and other related phenomena. Students group similar questions and determine a question that connects all the questions to create the DQB for the unit.
- *Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.*
    - Lesson 1 — Students analyze their questions to determine which can be investigated in the classroom.
    - Lesson 2 — Students return to the DQB and discuss which questions they can investigate in the classroom about the effects of changing the light in the box model. They frame a hypothesis for what they think will happen, based on observations from Lesson 1, and then investigate their questions by swapping the light.
    - Lesson 3— "SUPPORTING STUDENTS IN ENGAGING IN ASKING QUESTIONS AND DEFINING PROBLEMS Students are bringing foundational ideas about testable and untestable questions from elementary. In this lesson you will deepen their understanding of one type of testable question - experimental ones. Students will ask an experimental question to determine the relationship between the material (independent variable) and light transmitting and reflecting (dependent variables). The evidence they collect will help them better model the interaction between light and the one-way mirror" (TE, page 73).
- *Ask questions to determine relationships between independent and dependent variables and relationships in models.*
    - Lesson 3 — Students develop a testable question to determine how the materials that make up a one-way mirror, glass, and a regular mirror (independent variable) influence the amount of light that transmits through and reflects (dependent variable) off an object.

Students then use that question to plan an investigation, including the independent variable, dependent variable, and constants.

- *Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.*
    - Lesson 6 — Students ask questions to help them clarify and refine their model. In the previous lesson, students realized that their model was incomplete for explaining the phenomenon. This prompted additional investigation to figure out how light interacts with the eye. As students delve into how the eye works, they encounter new information about the structures of the eye and how those structures interact with light to change its direction. This new information helps students develop new questions. These questions assist them in refining their current model.

Developing and Using Models

- *Develop and/or use models to describe and/or predict phenomena*
    - Lesson 1 — "Students develop models to represent what they think is happening as parts of the system interact, leading to the phenomenon. They use a scale model that represents important components of the system in the video to provide additional observations of the phenomenon and test their ideas for explaining those observations. They also develop diagrammatic models to represent their thinking about the phenomenon. In doing so, students learn that models can be used to describe and explain a phenomenon."
    - Lesson 2 — "On day 2, students modify a model, based on evidence, to match what happens if a variable or component of a system (i.e., light) is changed. They consider the Initial Class Consensus Model from the end of Lesson 1 and then model what they think is happening when they test different lighting scenarios. "
    - Lesson 3 — "Students conduct two investigations in this lesson. In the first investigation, students observe what happens when light shines on a one-way mirror, glass, and a regular mirror. They observe that light reflects off each material, but only two materials transmit light. They develop an initial model to describe what they observe, which motivates the need to measure the amount of light that transmits through and reflects off each material. Students develop an experimental question, plan an investigation, then use light meters to measure the amount of reflected and transmitted light by the three materials. After analyzing class data, students revise the consensus model to more accurately describe what happens when light shines on each material. "
    - Lesson 5 — "Students revise a model to explain how light interacts with Mr. Bean and the men, as well as how light's interactions with the one-way mirror material, which reflects and transmits about the same amount of the light, causes both Mr. Bean and the men to see Mr. Bean. Students develop unobservable mechanisms that describe how light interacts with microscale structures within the one-way mirror to account for the observable phenomenon, in which the one-way mirror acts like a mirror on the light side and a window on the dark side."

    - Lesson 8 — "On day 1 students deepen their understanding of their model for explaining the one-way mirror phenomenon with a focus on the idea that light differential between the two sides of the system strengthens or weakens the phenomenon. They use this idea as they reconsider related phenomena and determine which phenomena may be explained using the light differential idea. They notice that they can observe a one-way mirror effect in situations that do not involve one-way mirror material, such as glass or plastic, but do involve a light differential. This prompts students to use their model to describe how changing a part of the system (swapping the one-way mirror for regular glass) can lead to similar outcomes as the one-way mirror phenomenon. They can support their initial explanations using the science ideas and model they have already developed as well as some new evidence they collect by investigating glass in their box models. "
- *Develop or modify a model—based on evidence—to match what happens if a variable or component of a system is changed.*
    - Lesson 2 — Students modify a model, based on evidence, to match what happens if a variable or component of a system (i.e., light) is changed. They consider the Initial Class Consensus Model from the end of Lesson 1 and then model what they think is happening when they test different lighting scenarios.
- *Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.*
    - Lesson 3 — Students use their physical model to conduct two investigations in this lesson. In the first investigation, students observe what happens when light shines on a one-way mirror, glass, and a regular mirror using their physical model. They observe that light reflects off each material, but only two materials transmit light. They develop an initial model(diagram) to describe what they observe, which motivates the need to measure the amount of light that transmits through and reflects off each material. Students develop an experimental question, plan an investigation, then use light meters to measure the amount of reflected and transmitted light by the three materials. Students record their data to represent the inputs and outputs of the system. After analyzing class data, students revise the consensus model to more accurately describe what happens when light shines on each material. However, students do not use their model to generate data about inputs and outputs at unobservable scales.
- *Develop a model to describe unobservable mechanisms.*
    - Lesson 4 — Students investigate microscale structures of the one-way mirror. These microscale structures cause light to transmit and reflect differently from regular glass and mirrors. Students use the structure of a one-way mirror to generate ideas about unobservable mechanisms that help to explain observations they have made of materials, both qualitatively and quantitatively. Students then develop a model to describe those unobservable mechanisms discussed.
    - Lesson 6 — After students investigate how light interacts with the structures of the eye, they leverage personal experiences to help them describe and model how the brain

processes signals to tell us what we "see" when there are multiple inputs of light that are detected by the eye. This helps students account for unobservable mechanisms that can explain why the student does not see the teacher/parent despite light reflecting off the teacher/parent and entering the Rockstar student's eye.

- *Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.*
    - Lesson 5 — Students revise a model to explain how light interacts with the Rockstar student and the teacher and parent, as well as how light's interactions with the one-way mirror material, which reflects and transmits about the same amount of the light, causes both the student and the parent/teacher to see the Rockstar student. This revised model shows the relationships among the observable phenomena variables. Using this model, students then develop unobservable mechanisms that describe how light interacts with microscale structures within the one-way mirror to account for the unobservable phenomenon, in which the one-way mirror acts like a mirror on the light side and a window on the dark side.

Constructing Explanations and Designing Solutions

- *Construct an explanation using models or representations.*
    - Lesson 7 — Students construct an explanation for the one-way mirror phenomenon using their models from Lessons 5 and 6 and science ideas developed and evidence gathered throughout the unit. Students explain different aspects of the one-way mirror phenomenon, first as a whole class and then individually.
- *Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real world phenomena, examples, or events.*
    - Lesson 8 — Students apply science ideas, their model, and the evidence they collected to construct an explanation for real-world phenomena in which glass acts similar to a one-way mirror in certain light conditions. They co-construct their explanations in a scaffolded way during a class Consensus Discussion and then individually on an assessment. They have to draw upon science ideas related to light reflecting off and transmitting through materials/objects, as well as science ideas related to how our eyes sense and detect light inputs and how the brain processes signals sent from the eyes.

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

The reviewers found extensive evidence that students have the opportunity to use or develop the DCIs in this unit because every lesson is in service of developing DCI understanding. Two physical science elements and one life science element are addressed and there is a tight focus on developing layered understanding of the targeted parts of the elements in all lessons.

PS4.B: Electromagnetic Radiation

- *When light shines on an object, it is reflected, ~~absorbed,~~ or transmitted through the object, depending on the object's material ~~and the frequency (color) of the light.~~* (strikeouts in the materials)
    - Lesson 1— Students make observations, discuss ideas, and make initial claims about what is causing the one-way mirror phenomenon to work including ideas about light and mirror material.
    - Lesson 2 — Students investigate how changing the amount of light shining in a room affects what can be seen in both rooms and model what they discovered about reflection and transmission using arrows.
    - Lesson 3 — Students investigate what happens when light is shone on a one-way mirror, a regular mirror, and plain glass. They model their discoveries using arrows.
    - Lesson 4 — Students read about and discuss how light behaves with a one-way mirror. They create a class model showing what they read.
    - Lesson 5 — Students create a Gotta-Have-It Checklist to show all the elements they need to include in an explanatory model for the phenomenon. The checklist includes light and how it reflects and transmits. Students model the interactions.
- *The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.*
    - Lesson 3 — Students investigate what happens when light is shone on a one-way mirror, a regular mirror, and plain glass. They model their discoveries using arrows.
    - Lesson 5 — Students create a Gotta-Have-It-Checklist to show all the elements they need to include in an explanatory model for the phenomenon. The checklist includes light and how it reflects and transmits. Students model the interactions using arrows and lines. The discussion prompts and consensus model bring out the idea that the light pathway lines would be straight.
    - Lesson 6 — Students investigate and summarize how light changes direction or bends when traveling through different transparent materials,

LS1.D: Information Processing

- *Each sense receptor responds to different inputs (electromagnetic, ~~mechanical, chemical~~), transmitting them as signals that travel along nerve ~~cells~~ to the brain. The signals are then processed in the brain, ~~resulting in immediate behaviors or memories~~* (strikeouts in the materials).
    - Lesson 6 — Students watch a video about how the eye works with the brain to process light inputs, then model what they saw.
    - Lesson 7 — Students use the models from Lessons 5 and 6 to explain how the adults are able to see the student. This includes the concept of how the eye and brain are involved.

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

The reviewers found adequate evidence that students have the opportunity to use or develop the CCCs in this unit because students engage with a total of two CCC elements in four out of the eight lessons. Where students engage with the CCC of **Cause and Effect**, they use a Grade 3–5 level element and not a middle school-level element.

Cause and Effect

- *Cause and effect relationships may be used to predict phenomena in natural or designed systems.*
    - Lesson 2 — Students revisit their questions from the DQB to identify questions that are able to be immediately tested in the classroom. They also generate new questions and add them to the DQB after sharing out the related phenomena each student brought to the discussion. To end the lesson and motivate further investigation, students are asked how the unit phenomenon would change if the materials change and how these ideas might be investigated. With this lesson, students predict the phenomenon using cause and effect relationships.
    - Lesson 7 — Students use cause and effect relationships to explain the one-way mirror phenomenon. However, students do not use cause and effect relationships to predict phenomena. In the document titled "Elements of SEPs and CCCs," this CCC is claimed as being used in Lesson 7: "While this specific element calls out using cause and effect relationships to make predictions about a phenomenon, using those cause effect relationships to explain a phenomenon is equally important in the 6–8th grade space." This is true, but is not evidence of the claimed CCC.

Systems and System Models

- *Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.*
    - Lesson 6 — Students use what they have observed in light investigations to make sense of what happens when light enters the student's eye so he can see himself. There is a large missed opportunity to have students explicitly connect to and think about systems interacting with each other, both the interaction of the eye system working together with the brain, and the system of light reflections in the room interacting with the parts of the human eye, when they are expected to propose the following steps in the process:
        1. "Light reflects off of Mr. Bean and then reaches the one-way mirror.
        2. That light then reflects off the one-way mirror and enters each of Mr. Bean's eyes to the lens.
        3. As the light passes through the lens, the lens causes the light to refract and focus light to a point on the retina at the back of his eye.
        4. Structures in the retina change the light signal to an electrical signal.
        5. The electrical signal travels from the retina to the brain along the optic nerve.
        6. The brain processes the electrical signal and Mr. Bean sees himself."

- Lesson 8 — Students talk about new phenomena that relate to the one-way mirror. The teacher is directed to ask students the following questions about the systems where these new phenomena occur, then have students turn and talk to answer them:
  - What are the important parts?
  - What are the interactions between those parts?

  However, the targeted element also addresses systems interacting with other systems, not only interactions between parts of a system, which was already part of the Grade 3–5 CCC grade band. Students then co-construct a simple definition for systems, which is also at the Grade 3–5 CCC element level, not the 6–8. Therefore, this student performance is not distinguished from a Grade 3–5-level performance.

- *Models can be used to represent systems and their interactions —such as inputs, processes and outputs—and energy, matter, and information flows within systems.*
  - Lesson 1 — Students create an initial model using pictures and words to explain how the parts interact to cause the phenomenon
  - Lesson 5 — Students use a model to show how light interacts with the parts of the system. Students co-construct a Gotta-Have-It-Checklist of what must be included in their models and the teacher is prompted to listen for and record student proposed inputs, outputs, and energy flows such as:
    - "Light source in Room A and no light source in Room B
    - Light leaving the light source
    - Light reflecting off student
    - One-way mirror between the rooms
    - The structure of the one-way mirror material (e.g., half silvered, silver structures, transparent structures)
    - Light reflecting off and transmitting through the one-way mirror material
    - Light from student entering student's eyes and the adult's eyes."

Structure and Function

- *Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.*
  - Lesson 4 — Students' model what a one-way mirror looks like at a microscale to explain the mechanism for how it works.
  - Lesson 6 — Students create a whole-class model representing video information of how light enters the eye and how it moves through to the brain and how this process depends on relationships among the system components.
- *Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.*
  - Lesson 3 — This element is claimed, but a connection to structure and function concepts is not explicitly made by the teacher or students because they do not use ideas about

choosing or designing materials to serve specific functions in reflecting and transmitting light. The only part of the element that is addressed is the idea that different materials have different properties, which if used alone is a DCI idea.

The reviewers also found evidence of the following additional unclaimed CCC element:
Scale, Proportion, and Quantity

- *Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.*
    - Lesson 4 — Students use a model of what a one-way mirror looks like at a microscale to explain the mechanism for how light behaves when interacting with materials.

Suggestions for Improvement

Science and Engineering Practices

- Consider varying the SEPs and methods students use to explain the phenomenon throughout the unit. Modeling is currently heavily utilized and may be too repetitive to hold students' interest.

Disciplinary Core Ideas

- Consider adding the DCI elements to the "SEP and CCC Elements" document to identify which elements (or parts of elements) are addressed in each lesson and how they develop over time.

Crosscutting Concepts

- Consider making the connection to interacting systems explicit in Lesson 6.
- Consider increasing the rigor level to move students beyond a simple listing of parts and definition of the word "systems" in Lesson 8.
- Consider explicitly identifying and embedding CCCs in additional lessons. Students could be facilitated to become aware that they are developing the CCCs and to use the language of the CCCs in their talk and modeling.

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	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena or designing solutions to problems because there is at least one central event where all students are expected to figure something out in a way that requires grade-appropriate elements of all three dimensions of the standards.

The following is a list of evidence related to this criterion:

- Lesson 2 — Students identify questions that can be tested and carry out an investigation to see how different materials in place of the one-way mirror change what can be seen. They develop a model to represent their findings, share and compare models with their peers, and make claims using evidence to explain how differences in material and light affect the ability to see objects during a Building Understandings Discussion. (**Developing and Using Models**: *Develop or modify a model — based on evidence — to match what happens if a variable or component of a system is changed***. Structure and Function:** *Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function*, and **PS4.B:** *When light shines on an object, it is reflected, ~~absorbed~~, or transmitted through the object, depending on the object's material ~~and the frequency (color) of the light~~*).
- Lesson 3 — After students conduct the investigation using a light meter to identify how much light is reflected and transmitted off of the different materials, students share classroom data, discuss in small groups and are asked to find patterns in the data. Students then participate in a Scientists Circle to make sense of what they noticed. Students identify that all materials reflect some amount of light, when most of the light transmits through a material, they can see through it, and when no light is transmitted, they cannot see through the material (**Developing and Using Models, Analyzing and Interpreting Data, PS4.B, Structure and Function).**
    - Lesson 4 — Students use the SEP of **Developing and Using Models** (element - *Develop a model to describe unobservable mechanisms)* to model what a one-way mirror looks like at a microscale to explain the mechanism for how it works (CCC element - *Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function)*. These help develop an understanding of how light behaves when interacting with materials (DCI element - *When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light*.) All three dimensions are applied here in service of developing an explanation for the one-way mirror anchoring phenomenon. An additional unclaimed CCC in **Scale, Proportion, and Quantity** is also addressed in this lesson: *Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.*
- Lesson 5 — Students use a model to show how light interacts with the parts of the system (SEP Element: *Develop and/or revise a model to show the relationships among variables, including*

those that are not observable but predict observable phenomena.). Students co-construct a Gotta-Have-It-Checklist" and the teacher is prompted to listen for and record student proposed inputs, outputs, and energy flow (CCC Element- *Models can be used to represent systems and their interactions —such as inputs, processes and outputs—and energy, matter, and information flows within systems.)* such as:

- "Light source in Room A and no light source in Room B
- Light leaving the light source
- Light reflecting off student
- One-way mirror between the rooms
- The structure of the one-way mirror material (e.g., half silvered, silver structures, transparent structures)
- Light reflecting off and transmitting through the one-way mirror material
- Light from student entering student's eyes and the adult's eyes."

The checklist includes light and how it reflects and transmits, addressing the DCI Element: *When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.*

- Lesson 6 — Students create an initial whole-class model (SEP Element - Develop and/or use a model to predict and/or describe phenomena) representing video information of how light enters the eye and how it moves through to the brain (DCI Element: *Each sense receptor responds to different inputs (electromagnetic, ~~mechanical, chemical~~), transmitting them as signals that travel along nerve ~~cells~~ to the brain. The signals are then processed in the brain, ~~resulting in immediate behaviors or memories)~~*. They then revise their explanatory whole class model for the anchoring phenomenon applying the new learning (CCC Element: *Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function*). However, even though students are interacting with all three dimensions, "all" students are not shown to interact as both models are created by the whole class. In addition, students are re-creating what they saw in a video in the first whole class model and aren't figuring it out for themselves.
- Lesson 7 — Students work to construct a written explanation using their models from previous lessons and their Progress Trackers/Science Ideas. Students begin by thinking about two questions related to the phenomenon: 1) Why does Mr. Bean see himself but not the other men? and 2) Why do the men see Mr. Bean? They begin by addressing the first question as a class. Several students share their key ideas with the whole class and begin thinking about the evidence they have collected to answer these questions. The whole class creates a shared explanation. They then construct an explanation individually for the second question. Students self-assess their explanation. First, they underline their descriptions of how/why, circle the evidence they used to support their claim, and box the places where interactions are described. They record notes about how they would like to revise their explanation. Students then provide peer feedback for another student's explanation. Students use those ideas to draft a revised

explanation and they identify the areas they revised and how the feedback led to the revision. "Supporting Students In Three-dimensional Learning: As you draft the class explanation, connect the practice of constructing explanations to the crosscutting concept of cause and effect. Specifically, call out that developing a how or why explanation (a mechanistic explanation) requires us to explain what causes the one-way mirror phenomenon, which is an effect we see. Encourage students to include multiple causes from the key science ideas list for the effect including: 1. how the half-silvered structure of the one-way mirror causes about the same amount of light to transmit and reflect off the one-way mirror. 2. how the structure of the eye, nerves, and brain causes the brain to respond to one light input" (TE, page 135). This performance uses elements of **Constructing Explanations and Designing Solutions, Systems and System Models, PS4.B** (Elements one and two), and **LS1.D.** Note that the claimed **Cause and Effect** performance is not related to a middle school-level element.

Suggestions for Improvement

Consider supporting students to be more aware of their use of the CCCs to help organize their thinking and their engagement in the three-dimensional learning process.

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 (PEs). In most cases student questions drive the current lesson and questions unanswered by the sense-making opportunities in that lesson drive the next lesson. In addition, the students return to the anchoring phenomenon in each lesson to work towards three targeted PEs from

both life science and physical science. The reviewers found that some guidance is provided to support the cultivation of new questions that arise from related phenomena or prior experiences.

The following is a list of evidence related to this criterion:

- Lesson 2 — Students revisit their questions from the DQB to identify questions that are able to be immediately tested in the classroom. They also generate new questions and add them to the DQB after sharing out the related phenomena each student brought to the discussion. To end the lesson and motivate further investigation, students are asked how the unit phenomenon would change if the materials change and how these ideas might be investigated.
- Lesson 3 — Students complete a discussion and model revision after testing how light interacts with three different materials. To transition to the next step, teachers are directed to "Summarize what we observed and determine next steps...Say, We know that light bounces off of all three materials, because we saw the light shine on each material and reflect back at us. We also know that light goes through glass and the one-way mirror, because we saw the light shine on each material, then go through and shine on the wall behind. What we don't know is how much light transmitted through or reflected off each material. How might measuring the amount of light that transmits and reflects be important for explaining the one-way mirror phenomenon? How could we determine how much light transmits and reflects?" (TE, page 72). This is much more teacher-directed rather than allowing students to summarize and discuss their own findings and identify questions they still need to answer. Here, the students return to the phenomenon to build upon their new understandings of the physical science DCIs. There is a chance for students to share their ideas about the questions that the teacher posed; however, students did not generate the summary and next questions themselves.
- Lesson 3 — The teacher leads a class discussion while students review the DQB questions. Students are asked about which questions about the mirror itself would be important to investigate to determine why it interacts differently with light than a mirror or glass. Students share the questions they think may help. After this discussion, the teacher does not allow the students to turn those questions into ideas for what to figure out next. Rather, the teacher is directed to say, "I think our next step is to try to figure out what the one-way mirror and the regular mirror have in common."
- Lesson 4 — Students are asked to turn and talk about the following questions: "What did we learn about the one-way mirror from the Measuring Light Investigation? How was the amount of light reflected or transmitted different from glass and mirrors? What other information do we need to explain the observed patterns?" (Lesson 4 Google Slide A)
- Lesson 6 — Students answer teacher-provided questions and the ideas about what to figure out next come from the teacher and not from the students. "What are some initial ideas about what could be happening to keep him from seeing the men? Listen for student ideas, such as: It's not enough light. It's less light than the light reflecting off Mr. Bean. Maybe the eye needs a certain amount of light to see something. Say, Let's keep these ideas in mind as we investigate the eye further. Let's make sure to circle back to them to decide why, if light from the men enters Mr. Bean's eye, he doesn't see them....Motivate first figuring out what is seen. Say, so we know Mr.

Bean sees himself. How is it that Mr. Bean sees the light input from himself, but not the light input from the men? Point to the two light inputs on the consensus model. Say, Maybe if we figure out why Mr. Bean can see one input, we can use that to understand why he doesn't see the other one." In this lesson, students return to the phenomenon to deepen their understanding of how the behavior of the light or changing of the materials to reflect the light (physical science DCI) affects what they can see (life science DCI).

- At the end of day one of Lesson 6, there is guidance for how to determine next steps that is teacher-centered: "Motivate next steps. Tell students, We now know what happens to one light input after it enters Mr. Bean's eyes. We can describe how the light that reflects off him into the one-way mirror, and back into his eyes is changed into a signal that his brain processes, enabling him to see himself. Our next step is to figure out what's going on with the second light input and why Mr. Bean can't see the men even though there is light that reflects off them and enters Mr. Bean's eyes, too. Have students return to their seats and close up for the day" (TE, page 124). The teacher is telling the students what is to be figured out next rather than students' questions motivating next steps.
- Lesson 8 — Students revisit the questions from their DQB as they first work in small groups to evaluate which questions they believe have been answered, those that might be only partially answered or not yet answered. Students use sticky dots to mark the questions. Students complete a Let's Answer Questions from our DQB chart (6.1 Lesson 8 handout) which asks students to list the questions and the evidence that answers the question. After the class discusses these questions, they then focus back on the original unit question of why do we sometimes see different things when looking at the same object?

The reviewers found evidence that the lessons help students develop toward proficiency of these targeted performance expectations:

- MS–PS4–2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
    - Lesson 1 — Students develop a model to describe how the one-way mirror phenomenon works including ideas about light and mirror material.
    - Lesson 2 — Students investigate how changing the amount of light shining in a room affects what can be seen in both rooms and model what they discovered about reflection and transmission using the models created in Lesson 1.
    - Lesson 3 — Students investigate what happens when light is shone on a one-way mirror, a regular mirror, and plain glass. They model their discoveries using arrows.
    - Lesson 4 — Students read about and discuss how light behaves with a one-way mirror. They create a class model showing what they read and describe how light waves react when coming in contact with different materials.
    - Lesson 5 — Students create a Gotta-Have-It-Checklist to show all the elements they need to include in an explanatory model for the phenomenon. The checklist includes light and how it reflects and transmits. Students model the interactions.

  - Lesson 6 — Students investigate and summarize how light changes direction or bends when traveling through different transparent materials.
- MS–LS1–8: Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
  - Lesson 6 — Students watch a video about how the eye works with the brain to process light inputs, then model what they saw. They use their models to gather data.
  - Lesson 7 — Students use the models from Lessons 5 and 6 to explain how the adults are able to see the student. This includes the concept of how the eye and brain are involved.

Suggestions for Improvement

- Consider providing opportunities for student generated questions to drive the next investigations.
- Consider utilizing the DQB to drive the learning across lessons rather than as a bookend experience to elicit student questions in Lessons 1 and 2 and then return at the end to see what questions were answered. This bookend model does not use the DQB to drive the learning across the unit.
- Consider providing opportunities for the teacher to use specific, in the moment student questions to spark conversations rather than relying heavily on scripted teacher prompts.

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 unit focuses on two domains that are both necessary for students to explain

the phenomenon. In addition, an example of applying the same CCC element of **Structure and Function** in both of these domains is present in the materials.

The following is a list of evidence related to the criterion:

- The unit integrates a Physical Science PE with a Life Science PE, appropriately making the link between what happens with light through the lens of reflection and transmission and why our eyes are able to process the input in order to see:
    - Lessons 1–7 — PE–MS–PS4–2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
    - Lessons 6–7 — PE–MS–LS1–8: Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
- Lesson 6 — Students explore naturally occurring structures (i.e., eye lens) and how the lens functions within a system based on shape and composition (CCC- Structure and Function).
- Lesson 7 — Students develop an explanation for the one-way mirror phenomenon by linking physical science ideas about when light shines on an object it is reflected or transmitted, depending on an object's material (DCI-PS4.D) with life science ideas about how sense receptors in the eye respond to electromagnetic inputs and transmit them as signals to the brain (DCI-LS1.D). Students create this explanation based on their created knowledge (from Lessons 1–6) of how these two systems (CCC- Systems and Systems Models) work together.
- Lesson 8 — Students apply science ideas and evidence from classroom investigations to construct an explanation for a common real-world phenomena in which our brain detects more or less prominent objects (DCI–LS1.D) due to the way light reflects off and transmit (DCI–PS4.D) through an object's structure (CCC– b). Students therefore use the same CCC element to connect two different disciplines.

Suggestions for Improvement

Strengthening the use of the CCCS in this unit generally and in particular looking for opportunities to apply the CCCs more commonly across domains could be helpful for students.

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 mathematics, ELA, history, social studies, or technical standards. Students use grade level writing and reading skills to explain and communicate their understanding of scientific concepts through ELA Speaking and Listening standards. Teacher support is provided for reading strategies for students struggling to read at grade level or reading complex texts and students are given multiple opportunities to engage in discourse throughout the unit. In addition, although there is one connection to a grade level mathematics standard, the reviewers noticed missed opportunities to fully connect to grade-appropriate mathematics expectations.

In this unit, students use grade level writing skills to explain and communicate their understanding of the scientific concepts/phenomena/results. Common Core standards used are listed in the materials at the end of each lesson. Below are several examples:

- **CCSS.ELA–Literacy.SL.6.1.c:** *Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.*
    - Lesson 1 — "When building the DQB, if a student forgets to explain why or how their question is linked to someone else's question, press that student to try to talk through their own thinking. This is a key way to emphasize the importance of listening to and building off each other's ideas, and it also helps to scaffold student thinking" (page 39).
- **CCSS.ELA-Literacy.SL.6.1.a**: *Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.*
    - Lesson 2 — "When the class is looking at each other's models and engaging in the Building Understandings Discussion to explain the different lighting scenarios, celebrate when students share evidence from the investigation or from their or another students' model. This is a key way to emphasize the importance of referring to evidence when discussing and reflecting on collective ideas" (Page 60).
    - Lesson 5 — When students are discussing models during the whole class discussions, encourage students to share the ideas they prepared during their individual or pair modeling work. Press students to share their rationale for their representations by asking for evidence from Lessons 2, 3, and 4 about light and the one-way mirror structure and function" (Page 111).
- **CCSS.ELA-LITERACY.SL.6.1:** *Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.*
    - Lesson 3 — "Following each investigation in this lesson, students engage in discussion when they work together in small groups to make and compare observations, as well as

when they work in whole group to analyze class data and revise class consensus models" (Page 89).

  - Lesson 6 — "There are numerous opportunities in this lesson for students to engage in discussions in pairs, small groups, and whole group. Some discussions are teacher-led, but not all. Guidance is included to help students share their experiences, express their own thinking, and build on the ideas of others as they work collaboratively to figure out why the Rock Star can see him/herself in the one-way mirror but can't see the parent/teacher on the other side. Additional strategies that can be used to help students include: Strategically pair and group students, provide multiple opportunities to respond to questions and share thinking (in pairs before whole group, for example) and allow students to use drawings as well as writing to express ideas" (Page 130).
  - Lesson 8 — "In this lesson, students are asked to engage in a variety of discussion formats with small groups and whole groups to share observations, draw conclusions and come to consensus in order to explain related phenomena. Students are asked to co-construct explanations for the new phenomena, orally, which require them to articulate a how or why account for the phenomenon and support their account with evidence. This evidence may draw from their use of physical models, observations in the real world, readings, images, videos, and classroom investigations" (Page 161).
- **CCSS.ELA-LITERACY.RST.6-8.3:** *Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.*
  - Lesson 3 — "Students follow a multistep procedure outlined in Measuring Light Investigation Procedures, which calls for students to use a light meter to measure the amount of light transmitted through and reflected by a one-way mirror, glass, and regular mirror. Students recorded their group data in a class chart and analyzed class data, looking for patterns that might help them explain the one-way mirror phenomenon" (Page 89).
- **CCSS.ELA-LITERACY.RST.6-8.2:** *Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.*
  - Lesson 4 — "The close reading strategy in this lesson connects to ELA standards that ask students to read text closely to determine the central ideas of the text and then to summarize those ideas. In step 3 of the reading strategy, students are asked to highlight the central ideas of the text that describe how one-way mirrors are made. Then, in step 4, they are asked to summarize those ideas in words and/or a diagram" (Page 100).
- **CCSS.ELA-LITERACY.SL.6.2:** *Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.*
  - Lesson 6 — "In this lesson, students gather and interpret information from video, numerous images, and text and use that information as evidence to figure out why Mr. Bean can see himself and can't see the men. If students struggle to gather information from any of these formats, look for alternative ways to present information, such as

paired reading of text, or utilize strategies that can help students gather the information they need, such as a graphic organizer or a close reading technique" (Page 130).

- **CCSS.ELA-Literacy.W.6.1B:** *Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text.*
- **CCSS.ELA-Literacy.W.6.2.b**: *Develop the topic with relevant facts, definitions, concrete details, quotations, or other information and examples.*
- **CCSS.ELA-Literacy.W.6.5:** *With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.*
    - Lesson 7 — Students are provided scaffolding for the written explanation through a whole class discussion. Then the students free-write for the rest of the explanation after seeing the whole class example. Students are supported to then revise their explanation by self-assessing and receiving peer feedback to ensure their explanation has several key elements.
- The writing ELA standards are not broadly represented in this unit. Students generally engage in verbal discussions, listing, and modeling or labeling to share ideas. This is a missed opportunity to develop student literacy in scientific writing, particularly in Middle School where more rigor than what is provided is appropriate. Most writing tasks are teacher directed and more structured; there is one opportunity to write a CER paragraph in Lesson 3 and students do not create any other written explanation (beyond listing or explaining student created diagrams) for a phenomenon until Lesson 7.

Students use mathematics skills to explain and understand scientific concepts, phenomena, and results; however, the two mathematics standards featured are from Grade 5. One grade appropriate standard is included in the Teacher Background Knowledge section (T.E., Page 12); however, the reviewers could not locate where this grade appropriate standard is used in the unit. The Teacher Background Knowledge section also contains information about the prerequisite math concepts students need to know before the unit. Examples of evidence of students using the two Grade 5 standards include:

- **CCSS.MATH.CONTENT.5.NBT.1** *Understand the place value system. Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.*
    - Lesson 3 — During the Measuring Light Investigation, students work in small groups using light meters to determine the amount of light transmitted through and reflected by a one-way mirror, glass, and regular mirror. Students are required to take readings that must be multiplied by 10 to determine the amount of light as measured in lux.
- **CCSS.MATH.CONTENT.5.NBT.2** *Understand the place value system. Explain patterns in the number of zeros of the product when multiplying a number by powers of 10 and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole number exponents to denote powers of 10.*
    - Lesson 3 — Students work collaboratively to develop a relative scale to accurately compare the light data collected for these three materials and to create a key that can

be used to show relative amounts of light transmitted through and reflected by the one-way mirror, glass, and regular mirror. The scale ranges from 0 to 16,000 lux or more, depending upon the amount of light emanating from the flashlights used in the investigation.

Suggestions for Improvement

An increased use of CCSS mathematics would provide more evidence for this criterion. Consider appropriate lessons (such as investigations where students generate data and lessons where students analyze data and graphs that are given to them) for students to use and develop the following:

- **CCSS.MATH. CONTENT.6. SP.B.4**: *Display numerical data in plots on a number line, including dot plots, histograms, and box plots.*
- **CCSS.MATH. CONTENT.6. SP.B.5:** *Summarize numerical data sets in relation to their context,* such as by:
    - **CCSS.MATH. CONTENT.6. SP.B.5.A:** *Reporting the number of observations.*
    - **CCSS.MATH. CONTENT.6. SP.B.5.B:** *Describing the nature of the attribute under investigation, including how it was measured and its units of measurement*
- **CCSS.MATH. CONTENT.6. G.A.1**: *Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems.*

Light and Matter: Why Do We Sometimes See Different Things When Looking at the Same Object?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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 the lessons focus on examples that most students in the class understand and there are some opportunities for students to experience some of the phenomena firsthand or through videos.

The following is a list of evidence related to this criterion:

- Students experience phenomena or design problems as directly as possible (firsthand or through media representations).
    - Students observe the one-way mirror phenomenon both through video and through first-hand modeling and experimentation. Lesson 8 loops students back to related phenomena in the real world that students may have seen—mirrored sunglasses, glass windows (mirrored and not).
- The materials include suggestions for how to connect instruction to the students' home, neighborhood, community, and culture as appropriate.
    - Students are assigned a self-documentation home learning assignment in Lesson 1; however, the reviewers did not find evidence that the unit provides guidance for completing steps 3–5. "The purpose of the self-documentation is to:
        1. have students "document" aspects of their everyday lives (e.g., about a phenomena or topic) using photos or other visual representation,
        2. cluster their photos into similar types of phenomena,
        3. identify which ones present possible areas of investigation for the unit,
        4. support students in engaging in investigations related to their focus, and

5. arrange for students to present their results to members of the community/STEM experts.

This home learning assignment supports students in step 1. They will complete step 2 on day 3 of Lesson 2 and will continue to add to the collection as they identify more phenomena."

- The materials provide opportunities for students to connect their explanation of a phenomenon to questions from their own experience.
  - Students have the opportunity to add their questions about the phenomenon to a Driving Question Board in Lessons 1 and 2.
  - Students choose 1 question from the DQB as a class to test.
  - Students evaluate the DQB in Lesson 8 and code whether they answered each question, didn't answer it, or partially answered it.

Suggestions for Improvement

- Consider explicitly stating in the lessons where teachers can assist students in connecting their questions to the targeted learning.
- Consider explicitly engaging in the phenomenon as directly as possible to generate compelling lines of student inquiry that come from their experience, community, and/or culture.

II.B. STUDENT IDEAS

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

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

The reviewers found extensive evidence that the materials provide students with opportunities to both share their ideas and thinking and respond to feedback on their ideas. The teacher is supported to act as an expert facilitator, drawing out student ideas while coordinating progress toward targeted learning. To assist both the teacher and the students with this, there are structured times indicated in the materials with icons for turn and talk with partners and with the class. Some lessons also include a scientists circle with discussion goals such as consensus and building understanding. Examples include:

- In Lesson 2, students test out different materials then model their findings and share those models with their peers in a Gallery Walk. Students compare and contrast models, talk with other students about their models, record ideas in their science notebook, and then participate

in a Scientists Circle for a Building Understandings Discussion to make claims with evidence about how humans see objects with light and how the model shows the path of light.

- Starting in Lesson 2, the class tracks their findings on a Science Ideas chart to identify the evidence they have gathered as they work to explain the phenomenon. Students also start a Progress Tracker in their science notebook and are encouraged to use their own diagrams and text to record their ideas. The Progress Tracker includes a column for the questions they are trying to figure out and the ideas they have figured out so far. Students add to the Science Ideas chart and update their Progress Tracker in Lesson 3 after they have analyzed data about the amount of light that reflects and transmits through different materials.
- Lesson 2 introduces how the student-generated, related phenomena connect to the bigger unit question about why humans may see different things while looking at the same object. They do this by sharing their related phenomena in a Scientists Circle and organizing them into categories.
- Teacher supports are provided throughout the unit to help draw out student ideas. For example, Lesson 3 provides background for the teacher on how the activities work together to bring out student ideas including providing guiding questions: "Through a collaborative process - starting with individual, then small-group, and finally whole-group discussion - students develop and revise shared models that represent a class consensus. Emphasize productive and respectful discourse during group and class discussions to support collaboration by asking questions like: How might we represent our Thinking? Does anyone disagree with the idea presented? Is there anything about the phenomenon that we haven't explained yet? Are there any gaps that need filling?" (Teacher's Edition, page 82)

Students also provide and receive peer and teacher feedback and demonstrate new thinking based on this feedback as well as personal reflection. For example:

- Lesson 2 — Students can use the self-assessment discussion rubric after they share their self-documentation examples to help them reflect on their participation.
- Lesson 3 — Students engage in a Gallery Walk. They observe the group models and ask questions in order to find similarities and differences between their model and those of other students.
- Lesson 7 — Students self-assess their own explanations using a set of elements that should be present in their explanations.
- Lesson 7 — Students provide and receive peer written feedback on their explanations using the elements that should be present in explanations. They are then given the chance to clarify and respond to the feedback by revising a final explanation. Students also reflect on and communicate about how they used their self-assessment and peer feedback to improve their work by explaining the feedback they decided to use, the feedback they didn't use and an explanation for why.
- Lesson 7 — The teacher is directed to "Use Rubric Explaining the one-way mirror phenomenon (page 205 of TE) to assess students and provide feedback to them on their

explanations and revisions." Students respectfully provide critiques about each other's explanations, pointing out places where their peers have done a complete job and posing questions and offering suggestions for how to improve the explanation. This is the only explicit teacher feedback direction given in the unit that the reviewers could locate. Explicit teacher feedback directions are not found in the Lessons 1–6 and 8. In addition, no explicit direction for how students might respond to this feedback was found. This is the last lesson where students are writing their final explanation, so the feedback would not be formative.

- Lesson 8 — Students complete a self-reflection on their learning experience in the unit. This self-reflection also asks about how they would engage in sensemaking discussions with their classmates. Students are encouraged to respond to the feedback on the unit assessment.

Suggestions for Improvement

Consider providing explicit direction for students to receive formative feedback from the teacher across lessons rather than only at the end of the unit.

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 clear guidance is provided for teachers to help acknowledge students' prior levels of proficiency. Unit materials are designed to build upon the typical level of proficiency students at this grade level have with each of the three dimensions. However, explicit guidance is not included about the learning progression within the unit.

The reviewers found multiple examples of the materials identifying prior learning in each of the three dimensions in the Teacher Background Knowledge section of the Teacher's Edition, as well as describing the prior learning being built upon:

- Page 7 — An explanation is provided as to why the previous DCI elements from grade 4 are intentionally reinforced. "You will see this DCI element reinforced during Lesson 2, with optional Building Prerequisite Understanding activities offered should students demonstrate they have not fully mastered this DCI"
- Page 7 — Rationale is provided about the unit expanding students' understanding of light to include Grade 6–8 elements from PS4.B: Electromagnetic Radiation as well as what parts of the DCI element are not covered in the unit. An explanation of how the partially addressed life science DCI fits into the unit is included. "Because this unit is the first unit in the OpenSciEd instructional materials, it is designed to be used at the start of the school year in 6th grade. Given this placement, the unit intentionally reinforces previous DCI elements from grade 4: PS4.B: Electromagnetic Radiation: an object can be seen when light reflected from its surface enters the eye"
- Page 7 — Rationale is provided about the DCI and which elements are addressed in this unit and which will be covered in future units: "1. This unit does not address absorption of light, which is taken up in lessons 7 and 8 of OpenSciEd Unit 6.2: How can containers keep stuff from warming up or cooling down? (Cup Design Unit). Should you teach Cup Design Unit following this unit, lesson 8 offers a related phenomenon that can help you transition from this unit to the Cup Design unit which focused on the use of one-way mirror film to make homes more energy efficient. 2. The DCI elements associated with Performance Expectation MS-PS4-2 span 5 instructional units in the OpenSciEd curriculum. This unit only address two of the elements and the other elements are covered elsewhere in the materials."
- Page 8 — "Students should come into this lesson with prerequisite understandings from 4th grade that light comes from a light source, bounces off objects and enters our eye, which is how we see things. Therefore, this lesson builds from: PS4.B: Electromagnetic Radiation: An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2)."
- Pages 8–10 — The SEP elements that are addressed in the unit and previous interactions with these elements are mentioned:
    - **Asking Questions and Defining Problems**: "Your students have already had a great deal of practice asking different kinds of questions during their elementary science experiences, though their background experiences may be uneven. At the elementary level, much of students' experiences will be closely tied to classroom investigations or Planning and Carrying Out Investigations. A notable shift at the middle grades is that students will start to ask questions well beyond investigations."
    - **Developing and Using Models**: "This model may use arrows to represent the line of sight or may use arrows to represent path light travels, depending on what knowledge students bring from 4th grade."
- Pages 11–12 – Prior knowledge and intended use of the CCC elements of **System and System Models** and **Structure and Function** are described in the "What should my students know from earlier grades or units" section:

  - "Students will work on their collaborative model building in this unit, reinforcing elements of practice from grades 3–5. They will engage in many consensus discussions around representations to use in models and work together to modify the representation as they see a need arise. For much of this work, the students will remain in the grades 3–5 territory, reinforcing (intentionally) this important element of practice." "Students will also reinforce their understanding of systems as a group of related parts that interact and will advance their understanding of systems by identifying boundaries to the system, considering light inputs within and beyond those boundaries, and recognizing that systems can be chunked into subsystems that are part of the larger, more complex system." (TE page 12)
  - "Students will have experiences in earlier grades related to structures and their function but will build on this crosscutting concept by investigating microscale structures that allow materials to function in predictable ways, such as the silvering of the one-way mirror."
- Page 12 — A section titled, "What are some common ideas students might have," provides teachers with expected prior learning and delineates some common student misconceptions.

The reviewers also found evidence of material to guide teachers in making adaptations, in each of the three dimensions, for students who are above or below the expected level of proficiency:

- Lessons 1–2 — Formative Assessment Guidance is provided throughout the lessons to help teachers identify if students are using a line of sight model, which would indicate the students have yet to master the related Grade 4 DCI. Examples of what to look for in students' models and ideas and optional Building Prerequisite Understandings activities to use if students are not coming into the unit with foundational understandings from Grade 4 are provided.
- The Teacher Background Knowledge section of the Teacher's Edition contains Supplemental Activities and how to use them. "Building prerequisite understanding activities offered early in the unit are designed to support students who have not mastered the prerequisite conceptual understandings from elementary school. Extension opportunity activities offered later in the unit are intended to be used for high interest learners, learners who have already met the performance expectations, or teachers who want to more fully develop students' understanding of some science concepts" (page 13).

Suggestions for Improvement

- Consider clearly explaining how students' prior learning is built piece by piece throughout the unit.
- Consider including adaptation opportunities throughout the unit.
- Consider strengthening the presence of CCCs throughout the unit and their application by students.

II.D. SCIENTIFIC ACCURACY

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

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

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

The following is a list of evidence related to this criterion:

- The Teacher's Edition (page 12) provides teachers with potential preconceptions students may bring to the unit.
- The phenomenon of a two-way mirror is appropriate for middle school students and offers logical access to the grade level standards.
- Students acquire information through grade level-appropriate text and media.
- There is extensive support embedded in the lessons to support teachers in facilitating talk and learning experiences that are accurate and appropriate. Some examples are:
    - In Lesson 1 Part 12: "Purpose of this discussion: to agree upon what we know, and more importantly, to agree on where we have gaps in our understanding of the phenomenon. Listen for these ideas:
        - Areas of agreement:
            - One side is dark and one side is light, and this is probably important.
            - The light side is the side where you see a reflection.
            - The dark side is the side where you see through the material.
            - The one-way mirror material can be both a mirror and a window, and this is likely related to the light.
        - Areas of disagreement or uncertainty:
            - arrows showing what you see or showing what the light is doing, but little agreement about how to use arrows

        - what the one-way mirror does that allows us to see through it and also see a reflection on it
        - how different amounts of light in the two rooms contribute to the outcome
        - how light's interaction with the one-way mirror causes the phenomenon
    - Lesson 1 Part 12 "Reintroduce the concept of modeling. Once the class has created a consensus diagram, step back and introduce students to the idea that we just developed a (diagrammatic or conceptual) model, which includes our ideas for how and why something in the world happens. Connect this concept to the work we just did: In trying to explain why Mr. Bean sees only himself, but the men see Mr. Bean, we developed a model."
    - Lesson 1 Part 12 — "Reiterate that scientists use models to explain phenomena and represent their ideas in a variety of ways - in this case, we used a diagrammatic model. Remind students we also used the box model to develop and test our ideas about what was happening in the real world. Tell them this model includes our current thinking but our ideas may change over the course of the unit, so we'll have opportunities to revise this model."
    - Lesson 3 Part 8 — "Introduce the investigation procedures and make a prediction. Pass out Measuring Light Investigation Procedures and tell students that this is the procedure for the Measuring Light Investigation. Show slide Q and say, Before you begin the investigation, take a few moments to individually predict what you think the light will do when it interacts with each material. Give students a few moments to complete that step, then display slide R. Tell students that the procedure is laid out in the handout, and that they should follow the procedure, step-by- step. In addition, tell them that each person in their group will need to take on one of the following roles:
        - Hold the flashlight
        - Hold the light meter
        - Hold the material
        - Read the light meter

      This is important because it will help the groups record data that is as precise as possible.
    - Lesson 3 Part 12 "Give students from different groups an opportunity to share the patterns they found in the data for transmitted and reflected light. If needed, show slide U (transmitted light) and slide V (reflected light) as students point out the patterns they found in the class data. Record students' ideas on chart paper. Look for the following ideas to surface:
        - Transmitted Light
            - The glass transmitted the most light. In fact, it transmitted a very large amount of the light that came from the flashlight.

        - The one-way mirror transmitted quite a bit less light than the glass.
        - The regular mirror did not transmit any light at all.
    - Reflected Light
        - The regular mirror reflected almost all the light from the flashlight. It reflected even more light than the glass transmitted.
        - The one-way mirror reflected just a bit more light than it transmitted.
        - The glass reflected a very small amount of light.

    After students share the patterns they found, have them rank the materials—from most to least—for the amount of light transmitted and the amount of light reflected. You can document this on chart paper, or you can write the name of each material on index cards and have students rank the materials on a continuum."
- Lesson 4 Part 1 "SUPPORTING STUDENTS IN ENGAGING IN CONSTRUCTING EXPLAINING AND DESIGNING SOLUTIONS: Scientific explanations include three important components: 1) they answer a question about a phenomenon, 2) include a how or why account of the phenomenon, and 3) are based on evidence. Lesson 4 marks an important transition for students as they start working towards explaining the one-way mirror phenomenon. They have a question about the phenomenon and have gathered evidence. They will continue to gather evidence in this lesson, but they will start working toward a how and why account for the one-way mirror phenomenon. By Lesson 7 students will develop a complete scientific explanation of the phenomenon."

Suggestions for Improvement

None

II.E. DIFFERENTIATED INSTRUCTION

Light and Matter: Why Do We Sometimes See Different Things When Looking at the Same Object?

EQuIP RUBRIC FOR SCIENCE EVALUATION

Provides guidance for teachers to support differentiated instruction by including:

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

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	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials provide guidance for teachers to support differentiated instruction because the materials provide teacher modeling, picture supports and graphic organizers, and sentence starters to support students. However, the reviewers felt that differentiation is not strongly present in the materials in the form of optional phenomena and tasks that provide more access to students, nor are supports present to explicitly meet the needs of students with high interest or the need for more challenge.

The following is a list of evidence related to this criterion:

- Appropriate reading, writing, listening, and/or speaking alternatives (e.g., scaffolded charts, photograph reference sheets) are provided for students who are English language learners, have special needs, or read well below the grade level. Related evidence includes:
  - The reviewers could not locate translations for reading passages in the unit.
  - A graphic organizer is provided for Lesson 1, 2, 5, 6, and 8
  - Photograph reference sheets are provided for:
    - Lesson 3 handout “Measuring Light Investigation Procedures”.
    - Lesson 4 reading handout “How is a one-way mirror made”.
    - Lesson 6 reading handout “How do eyeglasses help people see better”.
    - Lesson 8 handout “Explaining New Phenomena.”
  - Lesson 2 TE 47 states, “Supporting Emergent Multilinguals Learners: Scaffolds such as the Communicating in Scientific Ways sentence starters can model and facilitate oral or written language production skills.”
  - The readings are not provided at differentiated reading levels. The text contains difficult vocabulary words that would not be accessible to those reading far below grade level and English Language learners.

- Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations is provided. Related evidence includes:
    - Lesson 1 TE 22 states, "Supporting Emergent Multilingual Students: Keeping a science notebook gives students a space in which to communicate their developing understandings. Students should be encouraged to record their ideas using linguistic (e.g., written words) and non-linguistic modes (e.g., photographs, drawings, tables, graphs, mathematical equations, and measurements).
    - Students do not have the option of selecting and investigating different driving phenomena that are provided to be more accessible.
    - Students do not generally have the opportunity to perform different tasks, although they can select the DQB question they want to investigate in Lesson 2.
    - The teacher frequently creates a visual consensus model for the whole class.
    - Lesson 2 TE 53, "The gallery walk will support students in collectively making sense of these phenomena. It also presents an opportunity to work on the norm of "Moving our science thinking forward" as we work together to figure things out. Encourage students to be open to changing their minds if they see a good idea from someone else. Highlight norms from this category. We use and build on other's ideas. We are open to changing our minds. We challenge ourselves to think in new ways."
    - TE 56 "Building prerequisite understandings: Building Prerequisite Understanding Activities contains three Building Prerequisite Understandings activities to help students develop a path of light model to explain how we see objects. These three activities take varying amounts of time. You may choose to do one or all three depending on how much time your students need to work through these important foundational concepts. If you notice that your students are struggling or uncertain about how light allows us to see, then it is important to take time now to review the concepts so that all students can make progress later in the unit.
    - The authors in in their Response Document point out Lesson 7 TE 137, "If your students need additional support for writing in science, consider using a document camera and as students share their ideas orally, modeling how to write the explanation, and have students record the class explanation on "Explaining the one-way mirror phenomenon" Question 1 as a co-constructed model explanation to use as a resource when they write their own explanation individually. If your students need less support for writing in science, consider discussing the explanation orally and then having students individually record an explanation for "Explaining the one-way mirror phenomenon" Question 1." This seems to be addressing whole group needs and is supportive of student learning. However, if it is intended for the whole group, it is not an example of differentiation.
- Some possible questions are provided for the teacher that could be used as extensions, but directions are not provided in the materials to guide the teachers to use these as extensions.
    - Lesson 8 — "Extension opportunity: Throughout the course of this unit, your students may ask questions about light reflecting off mirrors and shiny surfaces compared to light

reflecting off non-shiny surfaces. These questions require additional science ideas to answer. The extension opportunity offered here allows students to investigate scattering and specular reflection in order to explain many of their everyday experiences. These activities can be completed by your entire class, if time permits, or offered to high interest learners, or those who have mastered the performance expectations in the main storyline."

Suggestions for Improvement

- Consider explicitly identifying opportunities in the materials to extend learning for students who need more challenging activities.
- Consider providing reading texts at different reading levels and in different languages.
- Consider explicitly naming alternate phenomena that can be investigated.
- Consider explicitly naming and describing "opportunities for differentiation" to help teachers in providing support for individual students who are at different learning levels.

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 strategies to provide coherence from lesson to lesson are present, such as asking a question at the end to prepare students to answer it the next day or viewing the original phenomenon video again through the lens of the current lesson. While students are engaged in sensemaking around the driving phenomenon across the course of the unit and students

create a Driving Question Board and add their questions, their questions from the board drive the learning in only two out of eight lessons. The reviewers found that the teacher-directed questions, not student questions, are the main driver of the unit.

The following is a list of evidence related to this criterion:

- The materials provide strategies for linking student engagement across lessons. For example:
    - In Lesson 1, students create a DQB to collect ideas about the one-way mirror phenomenon, cluster them together, and talk about ways to investigate the clusters.
    - In Lesson 2:
        - At the start: "Remind students that we agreed the one-way mirror looked like a mirror from one side and a window from the other side."
        - In Lesson 2, students choose a question from the DQB and test it.
        - At the end, students "generate new questions about related phenomena to add to the DQB. Give students time to generate new questions and add them to the DQB."
    - In Lesson 3:
        - At the start, "Remind students that in the previous class they were curious about how changing the material would change the phenomenon."
        - In Lesson 3, students choose a question from the DQB and test it.
        - At the end: "Navigate to the next lesson. As students finish updating their Progress Trackers, show slide Y and say, Now that we understand what happens when light shines on the one-way mirror, let's take a few moments to revisit the Driving Question Board. Have students gather around the DQB, then say, What questions do we have about the one-way mirror itself that could be important to investigate to understand why it interacts with light different from a mirror and a piece of glass? Give students a minute or two to look through the questions on the DQB. Let them share some of the questions they find. If not identified right away, point students toward their questions about what the one-way mirror is made of. Show slide Z and say, What do we think the one-way mirror is made of that allows it to do different things with light? Call on a few students to share their thinking. Students do not ask new questions.
    - In Lesson 4:
        - At the beginning, "Restate the class' mission using the DQB. Point to the category of questions the students had about the one-way mirror material, which was discussed at the end of Lesson 3 (e.g., these questions were likely "what" questions, such as "what is the one-way mirror made of?" and "how" questions, such as "how is the one-way mirror made"). Emphasize that the class agreed that answering these questions from the DQB could help the class make progress on explaining how the one-way mirror transmits and reflects about the same amount of light that shines on it, which the class agreed was important."

        - At the end, "Make connections to the one-way mirror phenomenon. Display slide J. Celebrate that the class just accomplished something important - they now have a mechanism to help them explain the one-way mirror phenomenon. Say, We've gathered a lot of evidence about the one-way mirror, but at the start of this class we didn't really know how it worked the way it did. We just figured out something big. We now know more about how it works. Have students Turn and Talk to discuss, How does the structure of the one-way mirror interacting with light cause the phenomenon? Tell students to be prepared to share their thinking to explain Mr. Bean in the next class.
        - Students do not ask new questions at the end
    - In Lesson 5:
        - At the start, students re-watch the original phenomenon video with a new lens of what is seen and what is not seen. Students do not ask new questions at the end.
        - No connection is made at the end to the next lesson.
    - In Lesson 6:
        - At the start, "Revisit what we figured out and our next steps. Display slide A, and say We know that Mr. Bean had two light inputs entering his eye: light that reflected off Mr. Bean to the one-way mirror back to his eye, and light that reflected off the men and transmitted through the one-way mirror to Mr. Bean's eye. We also know that the amount of light was different from each of these objects. Based on this, what did we expect Mr. Bean to be able to see? What did he actually see? Turn and talk with a partner." This is heavily teacher guided rather than supporting students to ask the questions.
        - "Close the lesson by saying, Now that we can explain why Mr. Bean sees himself and doesn't see the men, we are ready to develop an explanation for the one-way mirror phenomenon."
        - Students do not ask new questions at the end.
    - In Lesson 7:
        - The teacher poses the lesson questions students will answer in writing. The lesson ends with "Celebrate that we have explained the one-way mirror phenomenon."
        - Students do not ask new questions at the end.
    - In Lesson 8:
        - The lesson begins with, "Use probing questions to elevate the idea that there must be a difference in light in order for the one-way mirror phenomenon to occur." At the end, students return to the DQB to check off which of their questions have or have not been answered. While this does support unit coherence, the reviewers felt these activities could have been more student facilitated.

- The materials provide strategies for ensuring student sensemaking or problem-solving is linked to learning in all three dimensions. For example:
    - Each lesson has a lesson level performance expectation that is written as three-dimensional. However, they are not linked to NGSS elements.
    - An "Elements of SEPs and CCCs" document is included that lists claimed SEPS and CCCs by lesson.
    - An Assessment System Overview is provided with information about what to look for related to claimed SEPs and CCCs. DCIs are not included.
    - Support comments are provided on the side of the TE pages for claimed SEPs and CCCs. For example:
        - Lesson 1 TE 33, SUPPORTING STUDENTS IN ENGAGING IN DEVELOPING AND USING MODELS "Use this moment as an opportunity to expand on the practice of modeling. Describe it as a way of making thinking visible through diagrammatic representations, physical models, or even computer models. Foreground that modeling is a verb, which indicates it's not a "thing" but an "activity" that includes articulating, predicting, and testing ideas as we explain how or why phenomena occur. Emphasize that we use models for a purpose and that models can change as new information is learned. Avoid asking students to simply recite parts of a model as "facts"; push them to think about models as representations of ideas that can help us explain a phenomenon."

Suggestions for Improvement

Consider using the opportunities when students return to the DQB to prompt teachers to address which questions have been answered from the lessons already and to cultivate new student questions regarding the anchoring unit phenomenon.

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	Extensive *(None, Inadequate, Adequate, Extensive)*

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

Every lesson has multiple callouts for supporting students in developing and using specific SEPs. Asking Questions and Defining Problems and Developing and Using Models are the two focal practices for sensemaking in this unit. For example:

- Asking Questions and Defining Problems: Lesson 1 — "SUPPORTING STUDENTS IN ENGAGING IN ASKING QUESTIONS AND DEFINING PROBLEMS Initial questions about a phenomenon are intended to clarify what information is known and not known; there are often more questions than answers when scientists begin their investigations" (TE, Page 23).
- Lesson 1 — "SUPPORTING STUDENTS IN ENGAGING IN ASKING QUESTIONS AND DEFINING PROBLEMS Circulate among the groups to support students as they notice and wonder about the box model. In this unit, you will help your students become more intentional with the questions they ask. Now is an opportunity to formatively assess the types of questions they are asking about the phenomenon, and if the opportunity presents itself, to model how to turn a wondering from a close-ended question answered with a yes or no to an open-ended question that could be investigated" (TE, Page 28).
- Lesson 2 — "What to look/listen for: (1) Questions that focus on changing one aspect of the light in the box model at a time, (2) questions that are feasible in terms of time and materials, and (3) students framing hypotheses about what they expect to see.
- What to do: Focus on helping students consider changes they could make to the structure of the box model specific to the light. Then have students articulate why they think their question is feasible to investigate in the classroom. Press students to explain why they think their questions are feasible to investigate in the classroom. Point students back to the box models to help them evaluate the ease at which some of their questions could be investigated given limitations of the materials on hand.
- Lesson 3 — "SUPPORTING STUDENTS IN ENGAGING IN ASKING QUESTIONS AND DEFINING PROBLEMS Students are bringing foundational ideas about testable and untestable questions from elementary. In this lesson you will deepen their understanding of one type of testable question - experimental ones. Students will ask an experimental question to determine the relationship between the material (independent variable) and light transmitting and reflecting (dependent variables). The evidence they collect will help them better model the interaction between light and the one-way mirror" (TE, Page 73).
- Lesson 6 — "SUPPORTING STUDENTS IN ENGAGING IN ASKING QUESTIONS AND DEFINING PROBLEMS As students share what they have figured out about light that transmits through the lens of the human eye and draw tentative conclusions about what happens when light enters Mr. Bean's eyes so that he can see himself, listen for students to ask questions about the shape

and transparency of the lens of the human eye causing light to change direction or refract; and how the refracted light is focused to a point on the retina at the back of the eye. If students are struggling with how to revise their model, ask questions such as: What does your model need to explain or describe? What important components do you need to include in your model? What interactions do you need to represent in your model? How do the experiences you took part in help you revise our class model from day 1 so that it explains why Mr. Bean can't see the men?" (TE, Page 125).

Developing and Using Models:

- At the beginning of the unit, students create simple system models to show their initial thinking about the system involved in the phenomenon. The teacher provides support through demonstrating and explicitly teaching how to model. In Lesson 2, students modify a model to show their beginning thinking about what is happening using evidence from an investigation. In Lesson 3, students create a consensus model to represent and explain the results of an investigation including unseen moving matter elements such as reflection of light. In Lesson 5, students model to show what is happening with a one-way mirror at a microscale, they are now modeling the unseen structure to explain the mechanism for the phenomenon. In Lesson 6, students create a consensus model to show how the eye and brain systems interact with inputs of light to allow vision to occur, they are modeling interactions between multiple systems to explain the phenomenon. In Lesson 8, students use their constructed model to explain what will happen if elements of the model were changed. These examples show a strong progression in the complexity of student application of this SEP over the course of the unit.
    - Lesson 1 — "Students develop models to represent what they think is happening as parts of the system interact, leading to the phenomenon. They use a scale model that represents important components of the system in the video to provide additional observations of the phenomenon and test their ideas for explaining those observations. They also develop diagrammatic models to represent their thinking about the phenomenon. In doing so, students learn that models can be used to describe and explain a phenomenon. "
    - Lesson 2 — "On day 2, students modify a model, based on evidence, to match what happens if a variable or component of a system (i.e., light) is changed. They consider the Initial Class Consensus Model from the end of Lesson 1 and then model what they think is happening when they test different lighting scenarios. "
    - Lesson 3 — "Students conduct two investigations in this lesson. In the first investigation, students observe what happens when light shines on a one-way mirror, glass, and a regular mirror. They observe that light reflects off each material, but only two materials transmit light. They develop an initial model to describe what they observe, which motivates the need to measure the amount of light that transmits through and reflects off each material. Students develop an experimental question, plan an investigation, then use light meters to measure the amount of reflected and transmitted light by the

three materials. After analyzing class data, students revise the consensus model to more accurately describe what happens when light shines on each material. "

- Lesson 5 — "Students revise a model to explain how light interacts with Mr. Bean and the men, as well as how light's interactions with the one-way mirror material, which reflects and transmits about the same amount of the light, causes both Mr. Bean and the men to see Mr. Bean. Students develop unobservable mechanisms that describe how light interacts with microscale structures within the one-way mirror to account for the observable phenomenon, in which the one-way mirror acts like a mirror on the light side and a window on the dark side."
- Lesson 8 — "On day 1 students deepen their understanding of their model for explaining the one-way mirror phenomenon with a focus on the idea that light differential between the two sides of the system strengthens or weakens the phenomenon. They use this idea as they reconsider related phenomena and determine which phenomena may be explained using the light differential idea. They notice that they can observe a one-way mirror effect in situations that do not involve one-way mirror material, such as glass or plastic, but do involve a light differential. This prompts students to use their model to describe how changing a part of the system (swapping the one-way mirror for regular glass) can lead to similar outcomes as the one-way mirror phenomenon. They can support their initial explanations using the science ideas and model they have already developed as well as some new evidence they collect by investigating glass in their box models."

Support is provided for the development and use of elements one additional SEP category:

- **Constructing Explanations and Designing Solutions** (Lessons 4, 7, and 8)

Support for developing and integrating elements of the crosscutting concepts is provided in callouts for:

- **Systems and System Models** (Lessons 1, 5, and 8),
- **Structure and Function** (Lessons 2, 3, 4, and 6)

Suggestions for Improvement

None

Light and Matter: Why Do We Sometimes See Different Things When Looking at the Same Object?

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL CATEGORY II SCORE: 3 (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 or design solutions because students have multiple opportunities to show observable three-dimensional thinking. However, students are frequently heavily scaffolded through class talk and class modeling, which decreases individual opportunities for artifacts of student sensemaking and explaining. In addition, students do not have frequent opportunities to show individual thinking and sensemaking in formative tasks.

The following is a list of evidence related to this criterion:

- The Lesson 5 Class Consensus Model is claimed to be a Formative assessment in the Assessment System Overview document. Students create a whole class consensus model (SEP) to show their initial thinking about the system involved in the phenomenon and how those parts could be interacting (CCC) to cause (DCI) the phenomenon of a one-way mirror. However, these do not elicit and illuminate individual understanding, as all parts are co-constructed and modeled by the teacher and peers.
- Frequently, the models and explanations are co-created with the class or in a small group and the consensus model is usually drawn by the teacher. In these cases of heavy scaffolding, it is difficult to uncover evidence of individual student understanding and sensemaking.
- Examples of monitoring three-dimensional student performances:
    - Lesson 1 — Students engage in an individual pre-assessment as they model (SEP) to show their initial thinking about the system involved in the phenomenon and how those parts could be interacting (CCC) to cause (DCI) the phenomenon of a one-way mirror. Students continue working with this same model in Lesson 2.
    - Lesson 7 — Students engage with a summative assessment where they write (SEP) a final explanation of the phenomenon (DCI). They receive peer feedback on their writing and revise into a final draft. The self-assessment handout includes the tips “Did you include all the important parts in the system? Did you include how the parts interact?” (CCC) However, once again, the class first creates a whole class explanation that is modeled before they write to explain the rest of the phenomenon, creating an obstacle to eliciting what students actually understand before it is explained for them.

  - Lesson 8 — Students write and model to explain (SEP) how light behaves in a new scenario (DCI) and what could be changed in the system to change the phenomenon (CCC).
- Examples of monitoring two-dimensional student performances:
  - Lessons 2, 3, and 4 — Students engage in small group and whole class discussions that allow the teacher to observe student engagement with the DCI and SEPs. However, the middle school CCC elements are not explicitly present in these lessons and it is not possible to notice and record individual understanding of each dimension using this modality; therefore, this is only measuring two dimensions of student performance.

Suggestions for Improvement

- Consider increasing opportunities for students to sense-make and figure out individually and to show that thinking in observable ways.
- Consider decreasing the amount of scaffolding as it prevents students from fully engaging in sensemaking and figuring out at an individual level.

III.B. FORMATIVE	
Embeds formative assessment processes throughout that evaluate student learning to inform instruction.	
Rating for Criterion III.B. Formative	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials embed formative assessment processes throughout that evaluate student learning and inform instruction because the materials include explicit supports for formative assessment processes. The reviewers found that the formative assessment processes support student thinking across multiple dimensions and they attend to some issues of student equity.

The materials include explicit supports for formative assessment processes. For example:

- An Assessment System Overview Document is provided that lists identified assessments by lesson and describes their general purpose as pre-assessment, formative assessment, or

summative. The document describes lesson-by-lesson assessment opportunities telling when to check and what to look and listen for.,

- Examples of a range of possible student responses to the formative assessments, how to interpret them relative to learning goals, and how to respond to the different responses is not provided.
- Reviewers could not locate the Student Self-Assessment Discussion Rubric for Lessons 2, 6, and 7.
- Multiple opportunities in the TE lessons for assessment opportunities are identified.
- Lesson 1 — Students complete Handout 1 as a formative and pre-assessment.
- Lesson 2 — Students continue working with Handout 1. Support is provided to the teacher for next steps on TE 52 "What to do: Ask students what the arrows in their models represent to assess if students are using arrows to represent the path of light or line of sight. If you are hearing a lot of ideas about arrows representing the line of sight, be prepared to facilitate one or more of the Building Prerequisite Understanding activities described in Building Prerequisite Understanding Activities during the Building Understandings Discussion. These activities require a little preparation and materials but are easy ones to insert into your instruction. Being prepared to sidestep into these activities will allow you to respond just in time to your students' needs."

The formative assessment processes support student thinking across multiple dimensions. For example:

- Lesson 1 includes two opportunities for formative assessment that can be used as pre-assessments. The first of these opportunities is called out during the initial models to see if students are appropriately identifying the components and the path of light. While generating questions during the box model activity, the teacher guide indicates this as "an opportunity to formatively assess the types of questions they are asking about the phenomenon, and if the opportunity presents itself, to model how to turn a wondering from a close-ended question answered with a yes or no to an open-ended question that could be investigated." (Teacher's Edition, page 28) Another pre-assessment opportunity is identified as students are building the consensus model to gain insight on students' grasp of the Grade 4 light DCI concepts.

The formative assessment processes attend to some issues of student equity. For example:

- Lesson 2 — Students engage with a Self-Documentation activity which makes an individual formative assessment to see where students are with the concepts and dimensions. TE 59 "Self-documentation is a type of cultural formative assessment. This opportunity allows your insight into what students understand in terms of the phenomenon and allows aspects of students' cultural lives to surface (source: http://stemteachingtools.org/sp/self-doc). This is a good formative assessment opportunity to see how students make sense of the phenomenon as it applies to their lives."
- Lesson 5 — Students create individual explanatory models, then work in pairs to discuss, hold a class discussion about ideas and create a class model, then update individual models to reflect

the class model. Teachers can observe during these steps, but this would then seem to just reflect student ability to update their model to match the class thinking and not elicit individual student understanding to inform instruction. This is identified in the materials as a formative assessment in the assessment system document, and students may be engaging in formative assessment. However, there is no direction to teachers about assessing student work on this or providing feedback to students.

- Lesson 3 — The next steps provided are remedial in nature, "If students struggle to make comparisons, you can: Focus on students' observations of the amount of light transmitted through each material, one at a time, and document on chart paper. Then move to observations of the amount of light reflected off each material, one at a time, and document on chart paper. Compare the amount of light transmitted by the one-way mirror with the other two materials" (Teacher's Edition, page 72). This should help students see that the one-way mirror's data falls somewhere between the other two.
- Next steps are provided in the "What to do" assessment sections of the TE, but most provide some type of remedial suggestion for how to break down the activity in that moment to be more accessible for students, not direction on where to go next with instruction in response to the observed or collected student data.
- The following is a missed opportunity to provide specific examples and next steps: TE 74 What to do: "As students work, listen for the independent and dependent variables and the cause-and-effect relationship they identify as they construct their testable questions. Use that information to anticipate how you will guide the whole group discussion on day 2, and to consider the kinds of questions you might need to ask during the discussion."

Suggestions for Improvement

- Consider explicitly identifying which part of the NGSS teachers are assessing when using the lesson level PEs in the materials.
- Consider providing examples of different student responses to the assessments, including those from struggling students, students meeting the standards, and students performing above the expected level. In addition, consider including supports for how to respond to these different students.
- Consider providing more opportunities for students to show their thinking individually in observable ways.

III.C. SCORING GUIDANCE

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

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

The reviewers found adequate evidence that the materials include aligned rubrics and scoring guidelines that help the teacher interpret student performance for all three dimensions. Reviewers located scoring guidance for two out of eight lessons. However, assessment targets are often unclear from the scoring guidance. Some guidance is provided for teachers to interpret student progress, but students are not provided with a way to track their own progress.

The following is a list of evidence related to this criterion:

- Guidance is provided throughout the unit to give feedback to students.
- In Lesson 5, an Assessment Opportunity is identified as students develop a consensus model: "When to check for understanding: Review student models after they model what is seen" (Teacher's Edition, page 165). While it is labeled as a mid-point assessment, the only guidance is a sample model.
- Lesson 6 provides another Assessment Opportunity as students draw conclusions about how light interacts with the lens of an eye to see an object. There is a description of some instructional follow-ups for what to do if the students do not address all of the important science ideas.
- The reviewers could not locate any full rubrics that show the connection between the assessment, the targeted three-dimensional learning goals, and the learning experiences students had in the unit leading up to the assessment. For example:
    - In Lesson 7, a scoring rubric is provided on page 205 of the TE. The rubric lists the required elements for each answer and provides a column for the teacher to check "missing", "developing", or "mastered." A note at the bottom states, "The developing section of the rubric represents students who may have several important ideas described in the rubric that indicate progress toward mastery but there is still something notably missing in their response. Missing, on the other hand, indicates their response is missing many important ideas described in the rubric." The reviewers could not locate any guidance beyond that statement and no other supports in the rubric.
    - For the Lesson 8 summative assessment, a Scoring Guidance document is provided in the Lesson 8 Answer Key document. Guidance for teacher scoring is provided through a

list of responses that should be seen in student answers coded with a "+" or a "++." The coding system indicates a range of sample responses to determine the level of understanding demonstrated by the student. In addition, a chart is provided describing the grade-appropriate assessment targets for elements in all three dimensions, and guidance is provided to the teacher about what to look for in student performance related to these targeted elements. Two sample models (student work) are also provided. However, clear direction for the teacher on scoring a full range of student mastery levels in each of the dimensions is not provided. As a minor note, the teacher is told there is an option for students to use a CCC (**Systems and System Models**) that is not listed as a target for this assessment instead of another CCC (**Structure and Function**) that is listed. Therefore, the assessment target is somewhat unclear.

- Rubrics or scoring guidance were not found that are meant to be provided to students to help them monitor their own learning.

Suggestions for Improvement

- Consider providing more structured formative assessments early on in the unit that include an opportunity to assess each student individually. Consider providing a full rubric or scoring guidance for all of these assessments, describing student performance in all three dimensions. This would help support students in keeping track of their own progress.
- Consider expanding the scoring guidance for Lessons 7 and 8 to include full rubrics or scoring guidance that address:
    - The connection between the assessment, the targeted three-dimensional learning goals, and the learning experiences in the unit.
    - All dimensions being assessed, and guidance for how to interpret a range of student performance along all three dimensions as well as their integration and use in sensemaking.
    - How to provide feedback to students that is sufficient for them to understand their progress toward mastery in each targeted element of the three dimensions.
- For the Lesson 8 summative assessment, consider coding the "+" and "++" with the assessed dimensions they show mastery of, or alternately creating a leveled rubric for each of the three dimensions to support teachers in identifying and communicating to students their level of mastery or progress in each dimensional element.

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	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples because the text and vocabulary is appropriate for the grade level, students have the opportunity to show thinking using words, pictures, and talk, and students are able to engage in self-documentation of learning at home. In addition, the final assessment tasks allow students to choose between multiple modalities in their responses.

The following is a list of evidence related to this criterion:

- Text and vocabulary in assessment tasks is appropriate for middle school.
- Over the course of the unit, tasks and items make use of a variety of ways for students to convey their answers, such as talking about their ideas (all Lessons); creating visual representations through modeling (most Lessons), writing short answers (one CER), and writing more complex answers (Lesson 7). However, most of these modalities are not chosen by the students; students are typically told which modality to use or provided an organizer.
- In the Lesson 8 assessment "Portraits Through Glass," students have a choice of modality for some of the responses (words or pictures). For example: "Use words or pictures (or a combination) to explain where light travels that causes you to see the trees in this image" (Lesson 8 Assessment: Portraits Through Glass, page 1). An optional extension opportunity (Activity 3) in Lesson 8 also provides student choice of modality, but it may not be used in all classrooms (page 15).
- The materials provide support for students to ensure they understand assessment prompts in more than one modality. For example:
    - In Lesson 7, students have an assessment opportunity (page 143). They are asked to write an explanation individually after the class has worked through similar prompts together, so students are likely to understand the individual-level prompt. The teacher also is told to "remind students to explain one piece of feedback they used, one piece of feedback they didn't use, and why," indicating that students will have received some directions for the assessment orally.

  - In Lesson 8, the teacher talks through the assessment prompt images with the students (page 14) orally and with diagrams, making sure they understand the basic context of the task.
- Students use a Progress Tracker in Lessons 2–6 where they have their choice of how to record their thinking.
- Students engage with a self-documentation of learning which capitalizes on their personal ways of knowing and allows them to connect the learning to their lives.

Suggestions for Improvement

Consider explicitly stating where student choice of other modalities could be used in addition to the choice of words or pictures in the final Lesson 8 assessment.

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	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning because the materials include assessments that are sometimes designed to connect to learning goals and require students to apply appropriate elements of the three dimensions to make sense of the phenomenon.

All four of the assessment types mentioned in the criterion are present and information is provided for each assessment so that students can demonstrate their understanding of the same learning goals in a variety of ways. However, the assessments are mapped to the custom lesson level PEs rather than to the NGSS PEs or dimensional elements, making it unclear if and how each task assesses appropriate elements for middle school in all three dimensions.

Most or all tasks and items are multidimensional, there are significant tasks, and the measurement of the three dimensions proportionally matches up with the learning goals. For example:

- The unit provides pre-assessment, formative assessment, self-assessment, and summative assessment.
- The assessment system is described in a separate document.
- Lesson 1 — Students complete an initial diagram to explain the phenomenon. This can be used as a pre-assessment. "It is an opportunity to learn more about the ideas your students bring to this unit. Revealing these ideas early can help you be more strategic in how to build from and leverage student ideas across the unit" (Teacher's Edition, page 164).
- Lessons 2, 3, 4, and 6 — The Progress Tracker is used in most lessons and can be used as a way for students to express understanding of the concepts being presented. "The Progress Tracker is a thinking tool that was designed to help students keep track of important discoveries that the class makes while investigating phenomena and figure out how to prioritize and use those discoveries to develop a model to explain phenomena. It is important that what the students write in the Progress Tracker reflects their own thinking at that particular moment in time" (Teacher's Edition, page 165).
- Lessons 2, 5, 8, or "any time after a class discussion" — Self-assessments are included in the "Assessment Opportunity" callout boxes and are guided by a student self-assessment handout.

The rationale is located over the course of the materials for why all three dimensions are taught and assessed, including how each task measures student learning and provides feedback to teachers to inform instruction and students to inform learning. For example:

- Information is given for how each task will measure student learning. However, assessments are mapped to the unique lesson level performance expectations rather than to the NGSS PEs or to elements of the three dimensions, which makes it difficult to score in this category.
- Some assessments are two dimensional and do not include elicitation of student understanding of a grade appropriate CCC element.
- Multiple formats are used: performance task, writing, modeling, talk, constructed response.

Suggestions for Improvement

Consider explicitly identifying where each dimension is assessed and including methods for helping students use self-assessments as a way to measure growth in each dimension.

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	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials provide multiple opportunities for students to demonstrate performance of practices connected with their understanding of core ideas and crosscutting concepts. The reviewers found that the materials provide opportunities for students to engage in reflection and growth from written and oral feedback.

The following is a list of evidence related to this criterion:

- There are multiple, interconnected opportunities for students to demonstrate learning throughout the unit. All lessons build on one another with multiple opportunities for students to revise previous models as they gather new evidence.
- Students have multiple opportunities to demonstrate through performance what they are learning (talk, modeling, listening).
- Lesson 7 — Students have the opportunity to receive explicit feedback from peers in Lesson 7 where they give feedback on a written explanation and students then revise their original explanation based on the feedback.
- Below are examples showing the types of directions provided to the teacher in the "Assessment Opportunity" TE sections:
    - Lesson 2 TE 50 "What to do: Focus on helping students consider changes they could make to the structure of the box model specific to the light. Then have students articulate why they think their question is feasible to investigate in the classroom. Press students to explain why they think their questions are feasible to investigate in the classroom. Point students back to the box models to help them evaluate the ease at which some of their questions could be investigated given limitations of the materials on hand."
    - Lesson 2 TE 56 "What to do: If students don't have the 4th grade understanding that light bounces off objects and enters our eyes, do not continue the Building Understandings Discussion. Instead, do one or more of the Building Prerequisite Understanding activities presented in Building Prerequisite Understanding Activities now as a way to develop and reinforce these foundational concepts."
    - Lesson 2 TE 59 "Self-documentation is a type of cultural formative assessment. This opportunity allows you insight into what students understand in terms of the phenomenon and allows aspects of students' cultural lives to surface (source: http://stemteachingtools.org/sp/self-doc). This is a good formative assessment opportunity to see how students make sense of the phenomenon as it applies to their lives.
    - Lesson 3 TE 77 "What to do: If students have difficulty identifying independent and dependent variables for this investigation, write the question frame "How does

_____ affect _____?" on a whiteboard or chart paper. Write "one-way mirror," "glass," "regular mirror," "amount of light transmitted," and "amount of light reflected" on large sticky notes, and let students place a sticky note in each blank. Read and discuss the resulting question to determine if the cause-and-effect relationship is correct. Continue to use this process until students correctly identify which sticky notes have independent variables and which have dependent variables.

Suggestions for Improvement

Consider explicitly stating where written and oral feedback can be provided by the teacher to students to generate new thinking or connections to phenomenon.

Light and Matter: Why Do We Sometimes See Different Things When Looking at the Same Object?

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL CATEGORY III SCORE: **3** (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

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

Light and Matter: Why Do We Sometimes See Different Things When Looking at the Same Object?

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)