# Why Do We See Patterns in the Sky and What Else is Out There That We Can't See?

**DEVELOPER:** OpenSciEd

**GRADE:** Middle School **| DATE OF REVIEW:** July 2022

# Why Do We See Patterns in the Sky and What Else is Out There That We Can't See?

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

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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. The unit is strong in several areas, including students engaging in the three dimensions to make sense of phenomena, integration of the three dimensions, and supporting differentiated learning for specific student groups. The materials also support students to obtain information from observations made by different cultural groups.

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

- **Student questions or prior experiences motivating sense-making.** Many teacher question stems are provided in the materials, and student questions or prior experiences currently motivate sense-making in only about a third of the lessons. Students are not directed to ask questions in 10 of the 17 lessons and are not directed to share or use prior experiences in 12 of the 17 lessons.
- **Gradually increasing student proficiency in science and engineering practices over time.** Looking at specific SEPs across time, the degree of teacher support currently tends to stay at about the same level over time rather than gradually increasing expectations for students to engage in the SEP elements more independently or more deeply.
- **Students receiving and applying feedback from peers and the teacher.** Although students work continually with their peers and the teacher, formal guidance to engage in oral and written peer feedback with opportunities to revise specific learning artifacts based on the feedback is not included in the lessons. Likewise, formal guidance for the teacher to provide oral and written feedback on specific learning artifacts was not found.

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 doesn't support a claim that the criterion was met. The purple text in these review reports is written directly related to criteria and is meant to point out details that could be possible areas where there is room for improvement. Not all purple text lowers a score. Much of it is too minor to affect the score. For example, even criteria rated as Extensive could have purple text that is meant to be helpful for continuous improvement processes. In these cases, the criterion definitely WAS met. The purple text is simply not part of the argument for that Extensive rating.

# CATEGORY I

## NGSS 3D DESIGN

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

I.B. THREE DIMENSIONS

I.C. INTEGRATING THE THREE DIMENSIONS

I.D. UNIT COHERENCE

I.E. MULTIPLE SCIENCE DOMAINS

I.F. MATH AND ELA

# Why Do We See Patterns in the Sky and What Else is Out There That We Can't See?

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## 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.<br>Explaining Phenomena/Designing Solutions | Adequate |
|---|---|

The reviewers found adequate evidence that learning is driven by students making sense of phenomena or designing solutions to a problem because students engage deeply in making sense of a series of related phenomena across the unit. Student questions or prior experiences are used to motivate sense-making in about a third of the lessons.

The focus in the unit is on making sense of phenomena. In Lesson 1, the materials say "Though the unit is not driven by a single phenomenon, students will be making sense of a variety of investigative phenomena throughout the unit. Students will develop and revise models to explain investigative phenomena related to questions that developed from the anchor. In this way, the unit is still driven by student questions and making sense of phenomena. In Lesson 2, students will investigate and add the Earth's axis being tilted toward the North star. In Lesson 3 students will investigate and explain changes in the path and angle of the Sun from one year to the next and over thousands of years. In Lesson 4 they will revise their models to add that the angle of the Sun on Earth is responsible for the seasons. In Lesson 6 and 7 they will explain the current phase of the Moon the cyclic patterns of lunar phases, and a total solar eclipse. Lessons 8 through 11 will investigate why the color of the Sun changes at sunset, why the Moon changes color when it rises or sets and during a lunar eclipse, and why the sky is blue. Furthermore, in the final lesson set, students will expand their scale beyond the Earth–Sun–Moon system to answer their questions about the patterns apparent in the planets and stars and the role of gravity in causing those patterns" (Teacher Edition, page 45).

The topic of the solar system and the universe is the general topic that holds the learning sequence together. Students experience related phenomena throughout the unit. The following phenomena are used:

- Lesson 1: The materials state on page 15 of the Teacher Edition that the anchoring phenomenon for the unit is "Manhattanhenge." However, this phenomenon seems more like a unit launch rather than an anchor, as students experience and think about the Manhattanhenge phenomenon in Lesson 1 and explore it further in Lesson 5, but it is not referred to in any of the other lessons.
- Lesson 2: Students make sense of why the North Star stays in the same place in the sky to our eyes, the Sun and Moon appearing to rise in the East and set in the West, and stars appearing to move in a circular path around the North Star.
- Lesson 3: Students make sense of The Sun's height and path in the sky over time and how the amount of daylight changes over a year.
- Lesson 4: Students make sense of seasonal temperature differences seen in two cities and in the world.
- Lesson 5: Students make sense of the Manhattanhenge.
- Lesson 6: Students make sense of moon phases.
- Lesson 7: The phenomenon is a solar eclipse.
- Lesson 8: The phenomenon is a lunar eclipse.
- Lesson 9: The phenomenon is the changing color of the moon and sun.
- Lesson 10: Students make sense of the color of light changing through diluted milk. This also relates to Lesson 9 phenomenon.
- Lesson 11: Students make sense of rainbows.
- Lesson 12: Students make sense of moon color changes in an eclipse and the color of fish lures changing based on their position in the water.
- Lesson 13: Students make sense of the pattern of motion of Venus.
- Lesson 14: Students make sense of how some solar system objects orbit planets and others orbit the Sun.
- Lesson 15: Students make sense of craters on moons and planets that don't have an atmosphere.
- Lesson 16: Students make sense of how galaxies are seen in a Hubble image in an area that looks like empty space when seen with the naked eye, and that solar bodies cluster together.
- Lesson 17: Students make sense of how the Solar System, galaxies, and orbits are each seen to follow organized relationships and patterns of motion.

Student questions or prior experiences sometimes motivate sense-making in the unit. Related evidence includes:

- In this unit, students use a Design Question Board (DQB). The DQB gathers questions students have as they explore each of the related phenomena. The DQB is revisited in Lessons 2, 5, 7, 8, 13, 14, 15, 16, and 17. Additional advice to teachers for the DQB can be found in the OpenSciEd Teacher Handbook including "it is essential that the board be available to all students throughout the unit" (Teacher Handbook, page 22).

- Lesson 1: Students add their questions about related phenomena to a DQB and organize them. "Develop an initial driving question. Say, Now that we have written our questions, what question should we put at the top of our DQB?" (Teacher Edition, page 51). Students go home and discuss space-related phenomena with their families and bring back the family prior knowledge to the class that is then used to drive learning. "Wow, we got a lot of new ideas by polling our friends and families. Even though our friends and families have more experience than we do, they haven't been everywhere or around for that long when we think about how long humans have been observing the sky. How could we find out more about what patterns people across the world have observed in the sky over human history? Present slide J and have students turn and talk. Listen for students to suggest different modalities of storytelling, like videos, art, audio recordings, or podcasts" (Teacher Edition, page 38).
- Lesson 2: After watching a video students write their wonderings. "Say, Use the wonderings you had while watching the videos in class today to help create more questions to add to our DQB. Allow students a few minutes to record questions on sticky notes before moving into a scientists circle." Direction is not given to leverage student questions to drive sense-making, they are just elicited. Student prior experiences are not elicited or leveraged.
- Lesson 3: As students think about changing activities that occur in the year and observe the Sun's patterns, there are missed opportunities for students to ask questions (Teacher Edition, page 73).
- Lesson 7: "Watch a video of a solar eclipse. Present slide B. Say, I have a video here of a solar eclipse. Since we don't all have the same experiences or background knowledge about eclipses, we can watch this video together and see what we notice about what an eclipse is, and see what other questions we have about them. Have students make a Notice and Wonder chart in their notebooks to record their observations and questions"…."Share noticings and wonderings about solar eclipses" (Teacher Edition, page 147). Student questions are shared, but no discussion is prompted that connects the student questions to the learning that follows.
- Lesson 14: Students may make several connections to prior knowledge and previous units as they explore the simulation. "Support students in making these connections but also bear in mind that the goal of the simulation is to uncover the factors that affect the objects orbit, so other connections and ideas are ancillary" (Teacher Edition, page 273).

***Suggestions for Improvement***

- Consider adding facilitation guidance to increase the number of opportunities in which student questions and prior knowledge are intentionally leveraged to motivate students in sense-making of the phenomenon. Sample responses from students prior and background knowledge would be helpful as well.
- Consider whether the event of the Manhattanhenge should be identified as the anchoring phenomenon for this unit. Perhaps since it doesn't necessarily anchor the unit, the label of "anchor phenomenon" could be removed.

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| 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.<br>i. Provides opportunities to *develop and use* specific elements of the SEP(s).<br>ii. Provides opportunities to *develop and use* specific elements of the DCI(s).<br>iii. Provides opportunities to *develop and use* specific elements of the CCC(s). | |
| **Rating for Criterion I.B. Three Dimensions** | Adequate |

The reviewers found adequate evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions because students engage in learning activities that develop their skills and understanding in multiple elements of each dimension.

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

The reviewers found extensive evidence that students have the opportunity to use or develop the SEPs in this unit because every lesson deeply engages students in authentic development and use of the science and engineering practices in service of understanding and explaining phenomena.

**SEP Category addressed (or not addressed):**

**Asking Questions**

- *Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.*
    - Lesson 1: Students observe the Manhattanhenge phenomenon and ask questions that are captured on a Notice-Wonder poster (Teacher Edition, pages 31–32).

**Developing and Using Models:**

- *Develop and/or use a model to predict and/or describe phenomena.*
    - Lesson 1: Students develop initial models to describe Manhattanhenge and show why the phenomenon happens on certain days but not others. They share and explain their model to other students (Teacher Edition, page 33). Later, students work in small groups to choose a sky pattern from a list identified by the class and think together about the parts of the causal system. Students then individually model to describe the phenomenon and interactions between the parts of the system involved. Students present their models in small groups (Teacher Edition, page 43).

- Lesson 2: Students develop initial models to describe the related system elements and their interactions that could explain how/why we see the motion of different objects in the sky including Earth, Sun, Moon, North Star, the patterns of motion, and where someone is standing on Earth (Teacher Edition, page 63).
- Lesson 4: After conducting a light investigation and listening to a podcast that describes a different season pattern in Australia, students are asked to apply everything they have figured out so far to develop a Gotta-Have-It Checklist with a partner, then develop a model to describe and explain seasons and why the seasons in Australia are the opposite of those in the U.S. (Teacher Edition, pages 105–107).
- Lesson 6: Students individually develop an initial model to describe and explain why we see the current phase of the moon. Students co-create the list of model components that should be included to show interactions between them (Teacher Edition, page 130).
- Lesson 7: After viewing and discussing a solar eclipse video, students develop an initial model to describe and explain solar eclipses including the interactions happening with the objects in the system (Teacher Edition, pages 147–148). They then use a physical model to further explore eclipses. Students co-create a class model and students modify their own initial models (Teacher Edition, pages 149–150**).**

- *Develop or modify a model — based on evidence — to match what happens if a variable or component of a system is changed.*
    - Lesson 3: Students observe the motion of the Sun using planetarium software, then collect online data on the Sun's patterns over thousand of years (Teacher Edition, page 81). Students then use an initial physical model to investigate light patterns with an Earth-Sun system model and compare their results to the online data they collected (Teacher Edition, page 83). When they realize their results do not match the online data, students are asked what variable they can change in their model. Students realize the Earth's tilt can be changed and modify their physical model to reflect the Earth's tilt (Teacher Edition, page 87).
- *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 co-create a consensus model that revises their model of Manhattanhenge from Lesson 1. "Develop a Gotta-Have-It Checklist to explain Manhattanhenge. Display the Parts & interactions in the system that help explain the Manhattanhenge Phenomenon poster from Lesson 1. Present slide F. Say, Let's look back at the parts and interactions in the system that we used previously to help explain the Manhattanhenge Phenomenon poster and consider what we might want to add to it or change in light of all that we have figured out about the Earth-Sun system over the previous few lessons. Tell students to turn and talk with a partner to evaluate what parts and interactions still work and what ones we need to change based on our new understandings" (Teacher Edition, page 116).

    - Lesson 9: Students co-revise their initial consensus model of the Earth-Sun system to add Earth's atmosphere and think about how it might be related to the color phenomena they have been exploring (Teacher Edition, page 187).
    - Lesson 11: Students explore how light reacts with differently shaped clear objects, some that hold water (Teacher Edition, page 213). They then co-create a model to show one of the scenarios they explored (Teacher Edition, page 214). Students then model individually to describe and explain one of the other scenario phenomena using a co-constructed Gotta-Have-It Checklist (Teacher Edition, page 217).
- *Evaluate limitations of a model for a proposed object or tool.*
    - In Lesson 1, the teacher asks, "What might be some challenges or limitations with representing the Sun in a model at this scale?" (Teacher Edition, page 35).
    - In Lesson 6, "Consider asking students whether they notice any limitations of the model used in this interactive. Because students have previously discussed the variation in the amount of daylight over the year due to location and the tilt of the Earth, they may notice that this model does not account for the tilt of the Earth or its orientation in relation to the Sun" (Teacher Edition, page 134).
    - In Lesson 7, "During this discussion, students collaborate to build understandings about the boundaries and limitations of their models. They have a chance to reflect on the reasons they included or did not include certain components or interactions in the Earth-Sun-Moon system, and what representation was most helpful for developing certain ideas and why" (Teacher Edition, page 160).

**Planning and Carrying Out Investigations**

- *Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.*
    - Lesson 3: Students measure and record patterns of change in the amount of daylight over a year and patterns of change in the angle of the Sun (Teacher Edition, page 75). They then collect data from NOAA to see patterns of change over thousands of years (Teacher Edition, page 78). Students share their pattern data and analyze to discover that the Sun follows a stable, predictable pattern over hundreds of years (Teacher Edition, pages 80–81). Students use the data to build a physical model to test and explore how the Sun and Earth system might interact to explain day and night and seasons.
    - Lesson 4: Students compare temperature differences in different locations on Earth and identify a pattern in temperature. They use a physical model to conduct a light investigation and discover that the angle of the light affects the solar energy reaching an area and its temperature. They listen to a podcast that describes a different season pattern in Australia and then apply everything they have figured out so far to develop a Gotta-Have-It Checklist with a partner, then develop a model to describe and explain seasons and why the seasons in Australia are the opposite of those in the U.S.

    - Lesson 10: Students collect data as they investigate to see how light behaves as it shines through a medium (water with milk added). The data is used to develop thinking about how our atmosphere affects what we see and why objects in the sky appear to change color (Teacher Edition, pages 199–200).

**Analyzing and Interpreting Data**

- *Analyze and interpret data to provide evidence for phenomena.*
    - Lesson 2: Students "analyze data (from a video of a simulation or from a simulation) of the sky during the day and night over the course of 6 months of the day and night" (Teacher Edition, page 55) in order to explain why the North Star does not appear to move in the night sky.
    - Lesson 3: Students observe the motion of the Sun using planetarium software, then collect online data on the Sun's patterns over thousands of years. Students then use a physical model to investigate light patterns with an Earth-Sun system model and compare their results to the online data they collected (Teacher Edition, pages 83–85). When they realize their results do not match the online data, students are asked what variable they can change in their model. Students realize the Earth's tilt can be changed and modify their physical model to reflect the Earth's tilt (Teacher Edition, page 88).
    - Lesson 14: Students use a computer simulation of gravity and orbiting objects to figure out how two objects in a system interact, what the impact of the gravitation pull is on an object, and how force, speed, and distance have a relationship with the gravitational force on an object (Teacher Edition, page 273).
- *Analyze and interpret data to provide evidence for phenomena.*
    - Lesson 14: Students use a computer simulation of gravity and orbiting objects to figure out how two objects in a system interact, what the impact of the gravitation pull on an object is, and how force, speed, and distance have a relationship with the gravitational force on an object (Teacher Edition, page 273).
- *Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.*
    - Lesson 2: Students use a graphical display of the sun, moon, and stars in the sky to identify temporal and spatial relationships. Students model the temporal and spatial patterns of movement of objects in the sky due to the Earth's spin on an axis.

**Constructing Explanations and Designing Solutions**

- *Construct an explanation using models or representations.*
    - Lesson 13: Students choose between two model representations of the Earth-Sun-Venus system and explain which one supports an explanation of all the patterns of Venus that people on Earth have noted over time (Handout: Competing Models of the Venus-Earth-Sun System). Students use manipulatives and drawings to explain where Venus and Earth would need to be located to explain four different visible phenomena (Handout: Explaining Venus Related Patterns) (Teacher Edition, page 250).

- Lesson 17: Students develop a model to explain why objects in space clump together with lots of empty space in between. "We now know that other stars have rich systems as well, with planets and probably moons and other objects, but that there is a lot of empty space in between all these parts and systems. Why is it that we find things in space clumped together, with so much emptiness in between, instead of spreading out evenly? Can we make a model of the universe that shows and explains this structure?" (Teacher Edition, page 305)

- *Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.*
    - Lesson 12: Students apply science ideas about absorption, refraction, and transmission of different colors of light to a related fishing phenomenon. Students use evidence from what they learned about how light travels through different materials and how color and location can cause apparent changes.

**Engaging in Argument from Evidence**

- *Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.*
    - Lesson 16: Students as a whole class discuss the Shapley-Curtis Great Debate to demonstrate their interpretation of evidence of how things far away are organized in space.

**Obtaining, Evaluating, and Communicating Information**

- *Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).*
    - Lesson 4: Students read about the seasons to understand how people break them into patterns (Teacher Edition, pages 101–102).
    - Lesson 13: Students read about human observations from the past of Venus's patterns of motion (Teacher Edition, page 244).
    - Lesson 16: Students read about the debate over what is in space that we can't clearly see (Teacher Edition, page 295).

**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 students have the opportunity to develop understanding of multiple DCIs over multiple domains.

**DCI Category addressed (or not addressed)**

**ESS1.A: The Universe and Its Stars**

- *Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.*

- Lesson 1: Students observe that a phenomenon occurs as a pattern related to the motion of the Sun and they explain this pattern with an initial model.
- Lesson 2: Students observe the motion of the Sun, Moon, and stars in a computer simulation video, then develop a model to explain the patterns of motion they saw.
- Lesson 3: Students predict then observe the motion pattern of the Sun over the course of a year using video and a website. They create and revise a model of the Earth-Sun system to explain the pattern.
- Lesson 5: Students observe a video of the Sun's path over a year in New York to understand the pattern, then explain through modeling why the motion pattern results in Manhattanhenge.
- Lesson 6: Students observe images of Moon patterns from other cultures, develop an initial model to explain the pattern, and physically model the phases of the Moon to show why we see the current phase and to predict the next phase. Students use an online interactive to further understand the pattern.
- Lesson 7: Students observe a solar eclipse and model the motion patterns of the Sun, Moon, and Earth that must occur for an eclipse to happen. Students use the model to predict what motion pattern causes lunar eclipses.

- *Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.*
  - Lesson 16: Students observe a Hubble photo of galaxies and watch a movie that zooms out from the solar system to see the Milky Way Galaxy.
  - Lesson 17: Students create a small group model of the universe, revise the models, then develop a final classroom consensus model.

**ESS1.B: Earth and the Solar System**

- *The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.*
  - Lesson 3: Students create a model showing the Sun-Earth system.
  - Lesson 4: Students look at temperature differences on the Earth and investigate how the Sun-Earth system work together to effect seasons.
  - Lesson 6: Students observe and model the Earth-Sun-Moon system.
  - Lesson 13: Students read to learn about planet Venus and model the Earth-Venus system. They predict where Mercury's, Mars', and Jupiter's orbits are placed in the solar system and add them to their model. They learn the phrase "Solar System." They learn about past missions to other solar system bodies and explore infographics to learn about Venus, Mercury, the Moon, Gas Giants, Dwarf Planets, and the moons of Jupiter and Saturn. They use a simulation to observe the solar bodies and notice patterns related to orbits.
  - Lesson 14: Students think about and explore why solar system bodies orbit others. They use a simulation to test how size and distance of bodies affects their motion pattern

related to other nearby bodies. They connect this to prior experiences with magnets and develop a model that uses gravitational forces between objects to explain orbits.
    - Lesson 15: Students analyze images of solar system bodies that have craters and discuss to realize that meteor impacts occur and add matter to planets and moons that were once smaller. Students observe a computer model of the formation of the solar system and create comic book storyboards showing how the solar system was formed. The class co-creates a model from the storyboards to explain the formation of our solar system.

- *This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.*
    - Lesson 4: Seasons: Students observe temperature differences on Earth and conduct investigations and modeling to discover that Earth's tilt causes differences in sunlight energy on Earth's surface that results in the seasons.
    - Lesson 7: Students observe a solar eclipse and model the motion patterns of the Sun, Moon, and Earth that must occur for an eclipse to happen. Students co-create a class consensus model to show what causes lunar eclipses and to predict what they will see in a lunar eclipse.
    - Lesson 8: Students observe and order images of lunar eclipses showing the stages of the event.
- *The solar system appears to have formed from a disk of dust and gas drawn together by gravity.*
    - Lesson 15: Students analyze images of solar system bodies that have craters and discuss to realize that meteor impacts occur and add matter to planets and moons that were once smaller. Students observe a computer model of the formation of the solar system and create comic book storyboards showing how the solar system was formed. The class co-creates a model from the storyboards to explain the formation of our solar system.

**PS2.B: Types of Interactions**

- *Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.*
    - Lesson 14: Students think about and explore why solar system bodies orbit others. They use a simulation to test how size and distance of bodies affects their motion pattern related to other nearby bodies. When looking at the simulation, students notice red arrows indicating the amount of gravitational forces between two masses and when they manipulate the variables in the simulation, they explore factors that increase or decrease gravitational forces. They connect this to prior experiences with magnets and develop a model that uses gravitational forces between objects to explain orbits.

**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.*
  - Lesson 10: Students investigate and model color and brightness changes as light passes through a medium. They co-construct a model that includes the ideas of light bouncing off particles or reflecting. They learn the terms scatter, reflect, transmit (Teacher Edition, page 201) and notice/discuss the blue and orange light colors in their investigation.
  - Lesson 11: Students observe rainbows and water droplet shapes, then conduct an investigation to see how light reacts as it moves through different shapes with different media (air and water). They notice color splits and brightness changes. They model to show what happens to light as it passes through the different media. They create a Gotta-Have-It Checklist (Teacher Edition, page 217) to explain a related phenomenon that includes:
    - Light travels away from a light source in straight lines.
    - That direction of travel can shift/change when it enters a new medium (its angle of travel can change). Some colors of light change direction more than others when this happens.
    - When it shines on a rough object (screen) and makes an image, that light reflects/scatters off that object (screen) in all directions.
    - When it shines on a smooth object (mirror), that light reflects off in one direction.
    - Light coming from an image or object must reach our eyes in order for us to see it.
    - There should be an account for any changes in color or brightness in the light that they observed in the phenomena.
  - Lesson 12: Students model to explain how light, air, and water interact to cause the reddish color of the Moon in a lunar eclipse. They include ideas about light, reflection, refraction, and amount of light reaching the surface after passing through the atmosphere.
- *A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.*
  - In the lessons below, students explore color and brightness of light, and how light reacts going through a medium. However, students do not have the opportunity to directly discuss or model light as a wave model to explain the phenomena. The term wave is never used with students.
  - Lesson 9: Students observe photos taken from Earth and notice that solar objects change in color and brightness when seen near the horizon. They compare these to images taken from space outside of Earth's atmosphere and use diagrams to understand the atmosphere. They co-construct a model showing sunlight's path to Earth using arrows. No mention is made in Lesson 9 of a wave model of light being related to the color change they observe. The term wave is not used. The TE states, "Throughout this

lesson set, we are not describing differences between the wave and particle models of light" (Teacher Edition, page 180).

- Lesson 10: Students investigate and model color and brightness changes as light passes through a medium. They co-construct a model that includes the ideas of light bouncing off particles or reflecting. They learn the terms scatter, reflect, transmit (Teacher Edition, page 201) and notice/discuss the blue and orange light colors in their investigation. No mention is made in Lesson 10 of a wave model of light being related to the color change they observe. The term wave is not used.
- Lesson 11: Students observe rainbows and water droplet shapes, then conduct an investigation to see how light reacts as it moves through different shapes with different mediums (air and water). They notice color splits and brightness changes. They model to show what happens to light as it passes through the different media. The term wave is not used with students. They create a Gotta-Have-It Checklist to explain a related phenomenon that includes (Teacher Edition, page 217):
  - "Light travels away from a light source in straight lines."
  - "That direction of travel can shift/change when it enters a new medium (its angle of travel can change); some colors of light change direction more than others when this happens."
  - "When it shines on a rough object (screen) and makes an image, that light reflects/scatters off that object (screen) in all directions."
  - "When it shines on a smooth object (mirror), that light reflects off in one direction."
  - "Light coming from an image or object must reach our eyes in order for us to see it." Students should account for any changes in color or brightness in the light that they observed in the phenomena.

  Students also conduct an investigation to learn what happens when you combine different colors of light (Teacher Edition, page 219).
- Lesson 12: Students model to explain how light, air, and water interact to cause the reddish color of the Moon in a lunar eclipse. They include ideas about light, reflection, refraction, and amount of light reaching the surface after passing through the atmosphere. The term wave is not used with students.

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

The reviewers found adequate evidence that students have the opportunity to use the CCCs in this unit because students have numerous opportunities to use appropriate grade-level CCCs to make sense of phenomena. However, there is not evidence of students developing the elements of the CCCs.

**CCC Category addressed (or not addressed)**

**Patterns**

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

- Lesson 1: In Step 3, students turn and talk about the prompt, "If what we noticed about Manhattanhenge is a pattern, let's try and identify what is causing this to happen". Students use their model to discuss (Teacher Edition, page 34).
- Lesson 1: In Step 4, students respond to the prompt, "Is there anything else like that, where something happening way out in space is changing the patterns of what we see in the sky either during the day or during the night? Discuss this in your table group. As you circulate the room, accept all responses, but encourage students to focus on patterns they have seen or experienced." The patterns students name are listed in a common space (Teacher Edition, page 37). In Step 10, students return to the list to choose one of the patterns and create a model to explain the phenomenon. The teacher states, "On Day 1 of this lesson, when we were talking about Manhattanhenge, we ended up identifying important parts and interactions we would need to include in a model to explain why we can see that phenomenon only on certain days of the year… Let's use that sort of thinking going forward. Consider first what parts and interactions you think you are going to need to include in your system diagram of the phenomenon or pattern you choose" (Teacher Edition, page 43).
- Lesson 2: Students view a video simulation to observe patterns in the sky. They discuss and record the patterns they saw (Teacher Edition, page 60). Students then consider what can be causing the patterns and develop initial models to explain patterns of movement of objects in the sky (Teacher Edition, pages 62–63):
  - "What do the patterns we identified from observing the sky help us determine about the interactions of the Earth and Sun?"
  - "What do the patterns we identified from observing the sky help us determine about the interactions of the Earth and Moon?"
  - "What do the patterns we identified from observing the sky help us determine about the interactions of the Earth and North Star?"
  - "What do the patterns we identified from observing the sky help us determine about the interactions of the Earth and other stars? The other stars in the sky move around the North Star in a circle."
- Lesson 3: Students compare patterns from NOAA data and their physical model data and realize they do not agree with each other (Teacher Edition, page 87). Students must figure out that they need to change the tilt of the Earth in their physical model to see the pattern that matches their research data. "Say, Think back to what we did last class. Did the data we measured with our physical model match the data we recorded from the NOAA websites? Students will say it did not. Present slide S and say, Let's adjust our model to measure a 15–hour day and a 9–hour night. Look at our modeling assumptions… Which of the modeling assumptions would you change that would let us reach 15 hours of daylight? Go back to your group and think about which assumption we could change. After a few minutes, ask a few groups to share their ideas" (Teacher Edition, page 88).

- *Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems.*
    - Lesson 3: Students measure and record patterns of change in the amount of daylight over a year and patterns of change in the angle of the Sun (Teacher Edition, page 75). They then collect data from NOAA to see patterns of change over thousands of years (Teacher Edition, page 78). Students share their pattern data and analyze to discover that the Sun follows a stable, predictable pattern over hundreds of years. "How has the amount of daylight changed over 500 years? over 1,000 years? over 1,500 years? How has the solar elevation changed over 500 years? over 1,000 years? over 1,500 years? What's the relationship between the solar elevation and amount of daylight over hundreds of years? How does this compare to the data you recorded using the videos of the simulation? How does this data help explain why or how different communities created rituals to help mark and predict changes in the patterns of daylight during a year? What connections can we make between the patterns in the collected data in this lesson to the patterns identified by other civilizations we studied in earlier lessons?" (Teacher Edition, pages 80–81)
    - Lesson 4: Students use a physical model to gather data patterns related to how the height of the light source (the Sun) affects the amount of light on the object (the Earth). They gather numerical data and calculate to determine watts per square related to height. They use the resulting patterns to think about and explain seasonal temperature differences. "How do the angles of the pipe cleaners relate to the solar elevation measurements we made? What pattern do you see in the energy from light per square of paper data? What relationship was there between the angle of the Sun in the sky and the watts per square? Why? How can we use this relationship to help us explain why it is warmer in the summer here and colder in the winter?" (Teacher Edition, pages 99–101)
- *Graphs, charts, and images can be used to identify patterns in data.*
    - Lesson 13: Students analyze infographics with a partner and use them to identify patterns in data. "Examine any images, graphs, or tables. Write about any patterns you notice in each infographic or across infographics." "Discuss this question with your partner and then answer in your Progress Tracker- What new patterns do we see when we look more closely at other objects in the sky?" (Handout: Analyzing and Interpreting Data from Infographics Close Reading Protocol).

**Cause and Effect**

- *Cause and effect relationships may be used to predict phenomena in natural or designed systems.*
    - Lesson 11: Students use what they just discovered through the rainbow lab to predict what might happen if the colors could be recombined. "Briefly ask students to re-voice what they discovered during the rainbow lab. Pose the question, If we can separate white light into colors, what do you think we might see if we tried recombining the different colors back together? Ask for a show of hands of students who have some

ideas of what we might see happen. Say, Before I have any of you share, I'd like everyone to consider this question further and make some quick predictions with a partner" (Teacher Edition, page 218). No language in the TE or on Slide O prompts students to use cause and effect thinking to support or accomplish their predictions.

**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 9: Students use zoo- ins to think at different scales in their model. "Introduce the zoom-ins on our new atmosphere model. Say, In the past we have used zoom-in models to look at something really small. This is another situation where we can use similar thinking about what is happening at a different scale. Let's also think about what is different about the parts of the system that we are interested in at this zoomed-in scale. This zoom-in doesn't focus on particles, which we have included in the past to explain some phenomena. Instead we are zooming in on a smaller part of the Earth within the larger Earth–Sun system…Talk with a partner about what might be causing the change in color we've noticed. After reorienting to the zoom-ins, prompt the students to talk with a partner about the questions on the slide: What similarities and differences are there between what Person A and Person B are experiencing? Why might the sky look different to each of them?" (Teacher Edition, page 189).
    - Lesson 17: Students work in small groups in response to the prompt, "We now know that other stars have rich systems as well, with planets and probably moons and other objects, but that there is a lot of empty space in between all these parts and systems. Why is it that we find things in space clumped together, with so much emptiness in between, instead of spread out evenly? Can we make a model of the universe that shows and explains this structure?" (Teacher Edition, page 305).

**System and System Models**

- *Models are limited in that they only represent certain aspects of the system under study.*
    - Lesson 7: Students think about and discuss how the three models they created are limited. "Say, This model—'How often might we see a solar eclipse?'—looks pretty different from our first model 'How does a solar eclipse happen?' Does that mean that our first model was wrong? (No!) Use prompts such as the following to support students in continuing to compare and contrast these various iterations of the Earth-Sun-Moon system model. How did the parts and interactions in each of these models connect with each of the questions we were trying to figure out? What are some parts and interactions we didn't include in each model? Why did we leave those things out?" (Teacher Edition, page 160)
- *Models can be used to represent systems and their interactions — such as inputs, processes and outputs — and energy and matter flows within systems.*

- Lesson 7: Students make sense of eclipses using model thinking to delve into the system and its interactions. "Decide where to go next. Display slide E. Say, What could we do to help us understand what causes an eclipse? Sample student responses: Create a physical model (like we have done before). Work with a simulation. Look at photographs of the Earth-Sun-Moon system from afar. Do research (i.e., talking to a scientist, Googling it). Say, Let's see if we can figure this out by modeling the system using a physical model. Display slide F. Say, What will we need to include in our physical model to make sense of the cause of eclipses? Reference your list of the 'Important Parts and Interactions to Include in the Model' from the previous lesson and ask if anything needs to be added or removed. As students make suggestions, follow up by asking why their suggested objects and interactions are important to include" (Teacher Edition, page 148).
- Lesson 7: Students work in groups to sense-make together about solar eclipses using modeling. "Model a solar eclipse in groups. Using the provided modeling supplies, ask students to work in groups to use the physical model to demonstrate what is going on during a solar eclipse like the one we saw in the video. After some initial group work time, this will be an iterative process of students modeling in small groups, responding to teacher questions, and sharing across the room. How are the Earth, Sun, and Moon interacting to make the eclipse happen? How do you know the observer (push pin) will see a solar eclipse? Are there areas of Earth that would not see this eclipse? How do you know? How did these physical modeling materials help you describe and explain a solar eclipse?" (Teacher Edition, page 149)

- *Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.*
  - Lesson 1: The teacher is prompted to ask, "Are there any other interactions in the system with other objects/parts that we should take into account in order to explain changes happening over something like a month? What else is changing over that period of time?" (Teacher Edition, page 36)

**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 10: After conducting an investigation using a model to represent Earth's atmosphere, students make sense of the data to understand how the relationships between parts cause the phenomenon. "Making sense of the data:
    - 1. How does the amount of the simulated atmosphere (the distance the light must pass through and/or the density of the particles in it) affect the brightness of the light from the simulated sun after the light travels through it?

- 2. How does the amount of the simulated atmosphere (the distance the light must pass through and/or the density of the particles in it) affect the color of light from the simulated sun after the light travels through it?
- 3. Based on what you could see from the 'imaginary cutaway' view of the atmosphere, what do you think is causing the changes we see when viewing light through the atmosphere?" (Handout: Investigation Elements Map, Predictions, and Results).

***Suggestions for Improvement***

**Science and Engineering Practices**
N/A

**Disciplinary Core Ideas**

- To fully address the DCI element *"A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media,"* consider adding the term "wave" in the lessons that address light with a middle-school appropriate scaffold of what the term means. Since some lessons are focused on making sense of color, this DCI element is closely connected, so it is a missed opportunity not to address the first part of this element, connecting student learning to waves.

**Crosscutting Concepts**

- Consider adding explicit use of CCC ideas such that they could be applied again in other contexts in future lessons.
- In Lesson 11, adding language that asks students to consider the cause-and-effect relationships they discovered in the earlier labs and discussions could support students to fully use the claimed **Cause and Effect** element.

## I.C. INTEGRATING THE THREE DIMENSIONS

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

| | |
|---|---|
| **Rating for Criterion I.C. Integrating the Three Dimensions** | *Extensive* |

# Why Do We See Patterns in the Sky and What Else is Out There That We Can't See?



The reviewers found extensive evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena or designing solutions to problems because all lessons engage students in grade-level appropriate SEPs, DCIs, and CCCs in integrated and coherent service of understanding and explaining lesson level phenomena.

Related evidence includes:

- Lesson 1: Students observe the phenomenon of Manhattanhenge and ask questions. The teacher is prompted to ask, "Are there any other interactions in the system with other objects/parts that we should take into account in order to explain changes happening over something like a month? What else is changing over that period of time?" They develop an initial model to describe the phenomenon pattern and to explain what might be causing it to happen. They list other sky phenomena that follow patterns and create an initial model to describe the patterns and explain one of the phenomena.
    - SEP: *Develop and/or use a model to predict and/or describe phenomena*
    - DCI: *Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.*
    - CCC: *Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.*
- Lesson 3: Students observe the motion of the Sun using software, then collect online data of the Sun's motion over thousands of years. They engage in physical modeling of the Earth-Sun system and realize their physical model data pattern does not match their research data pattern. They figure out they need to change the tilt of the Earth to achieve matching results. Students create a model of the Earth-Sun system that explains the patterns of the amount of daylight and the pattern of the Sun's changing position in the sky over a year.
    - SEP: *Develop or modify a model — based on evidence — to match what happens if a variable or component of a system is changed.*
    - SEP: *Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.*
    - DCI: *Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.*
    - CCC: *Patterns in rates of change and other numerical relationships can provide information about natura-l and human designed systems.*
- Lesson 7: After viewing and discussing a solar eclipse video, students develop an initial model to describe and model the motion patterns of the Sun, Moon, and Earth that must occur for an eclipse to happen, including the interactions happening with the objects in the system. They then use a physical model to further explore eclipses. Students co-create a class model and students modify their own initial models. They think about and identify how the three models they created are limited and use the model to predict what motion pattern causes lunar eclipses.
    - SEP: *Develop and/or use a model to predict and/or describe phenomena.*

- DCI: *Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.*
- CCC: *Models are limited in that they only represent certain aspects of the system under study.*

- Lesson 10: Students investigate and model color and brightness changes as light passes through a medium. They co-construct a model that includes the ideas of light bouncing off particles or reflecting. Students work with a partner to think about how the materials they are using in the model correlate to aspects in the real world and how. They learn the terms scatter, reflect, transmit and notice/discuss the blue and orange light colors in their investigation. The data are used to develop thinking about how our atmosphere affects what we see and why objects in the sky appear to change color.
  - SEP: *Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.*
  - DCI: *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.*
  - CCC: *Models can be used to represent systems and their interactions — such as inputs, processes and outputs — and energy and matter flows within systems.*
- Lesson 11: Students observe rainbows and water droplet shapes, then conduct an investigation to see how light reacts as it moves through different shapes with different mediums (air and water). They notice color splits and brightness changes. They model to show what happens to light as it passes through the different media. They create a Gotta-Have-It Checklist to explain a related phenomenon. Students use data to develop thinking about what happens to sunlight when it hits water droplets in Earth's atmosphere and how this can explain rainbows. Students use what they just discovered through the rainbow lab to predict what might happen if the colors could be recombined.
  - SEP: *Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.*
  - DCI: *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.*
  - CCC: *Cause and effect relationships may be used to predict phenomena in natural or designed systems.*
- Lesson 17: Students develop a model to explain why objects in space clump together with lots of empty space in between. "We now know that other stars have rich systems as well, with planets and probably moons and other objects, but that there is a lot of empty space in between all these parts and systems. Why is it that we find things in space clumped together, with so much emptiness in between, instead of spreading out evenly? Can we make a model of the universe that shows and explains this structure?" Students include views showing multiple scales as part of their explanatory model.
  - SEP: *Construct an explanation using models or representations.*

- DCI: *The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.*
- DCI: *Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.*
- DCI: *Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.*
- CCC: *Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.*

***Suggestions for Improvement***

N/A

## I.D. UNIT COHERENCE

Lessons fit together to target a set of performance expectations.

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

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

| Rating for Criterion I.D. Unit Coherence | *Extensive* |
|---|---|

The reviewers found extensive evidence that lessons fit together coherently to target a set of performance expectations because students have the opportunity to engage in learning with five PEs that connect coherently across time and to the selected phenomena. Students use a DQB to record questions and regularly revisit it to take stock of what they have answered. Students have the opportunity to ask new questions in almost half of the lessons.

The unit supports students in building toward the following claimed PEs:

- **MS-ESS1-1**. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
  - Lesson 4: Students analyze seasonal temperature data, then build a physical model to explore and understand Earth's tilt related to sunlight.

  - Lesson 6: Students build a physical model and use an online interactive to make sense of moon phases and use it to predict the next phase of the Moon.
  - Lesson 7: Students observe a solar eclipse, develop an initial model, build physical models to explore and develop understanding, and develop a consensus model to explain the phenomenon. They also build predictive models of lunar eclipses.
  - Lesson 8: Students observe lunar eclipses and compare them to their predictive model.
- **MS-ESS1-2**. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
  - Lesson 14: Students use a simulation to explore how mass affects gravitational force and how this affects orbiting bodies.
  - Lesson 15: Students develop storyboards showing that the solar system is held together by gravity.
  - Lesson 17: Students use a model to explain the role gravity plays in organizing systems in the universe.
- **MS-ESS1-3**. Analyze and interpret data to determine scale properties of objects in the solar system.
  - Lesson 16: Students observe the universe system at different scales using a video that zooms continuously outward.
  - Lesson 17: Students develop posters modeling the universe at multiple scales.
- **MS-PS2-4**. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
  - Lesson 14: Students use a simulation to explore how mass affects gravitational force and how this affects orbiting bodies.
- **MS-PS4-2**. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
  - Lesson 10: Students use materials to explore how light is affected as it transmits through liquid. The term or concept of waves is not used with students.
  - Lesson 11: Students observe rainbow images and raindrop shapes then investigate how the shape of an object changes the color of light as it is transmitted through. The terms scatter, reflect, and transmit are added to the word wall. The term or concept of waves is not used with students in the unit.

At the start of all lessons, there is a navigation section where teachers have a brief discussion of what they did in the last session and what they are trying to figure out. They also end with a navigation to the next lesson. For example:

- Lesson 2: "Say, Last time we were together, we met with a trusted member of our community to examine patterns in the sky using Lesson 1 Community Guide for Looking at the Sky. What were some of the things you observed in the sky that we were interested in observing to figure out more about some of these patterns? Turn and talk with a partner" (Teacher Edition, page 59).

- Lesson 10: "Navigate to next time's work. Say, We have some interesting ideas about both white light and the colors of light we see. Why are those colors there after light passes through matter? Next time we're together, let's dig into some of our related phenomena to help us better understand light and color" (Teacher Edition, page 202).
- Lesson 12: "Say, Thanks for all of your deep thinking today. Let's start next time by not only celebrating what we have figured out but also seeing in what clusters on our DQB we still have unanswered questions" (Teacher Edition, page 235).

Students are supported to cultivate new questions that build on what students figured out. For example:

- Lesson 4: After students examine data of season temperature differences and distance from the sun, they generate new questions based on what they found out. "If the distance from the Sun can't explain the temperature differences across a year (seasons), what can? What causes it to be warmer in the summer (in the Northern Hemisphere) and cooler in the winter then, if it's not because we are closer to the Sun?" (Teacher Edition, page 98)
- Lesson 13: "Say, We have spent a lot of time thinking about how objects in the sky impact our daily lives. Remember back to the podcasts from Lesson 1 that planets visible in the night sky also impacted people's daily lives. Handout Experiences and Connections with the Planets and have students individually answer one or more questions on the table on Experiences and Connections with the Planets for about 4 minutes. Then display slide F have students discuss their answers with partners for an additional 4 minutes, recording new questions they have about the planets. Invite students to add new questions to the Driving Question Board" (Teacher Edition, page 243).

  Lesson 17: "Have students work in pairs to evaluate what questions the class has answered from the DQB. Display slide H. Provide students with Reviewing Our Driving Question Board, which you created to contain all the student questions from the DQB, and have students tape it into their science notebooks. Have students work with a partner to mark questions they think the class has answered: We did not answer this question or any parts of it yet: Our class answered some parts of this question, or I think I could answer some parts of this question: ✓ Our class answered this question, or using the ideas we have developed, I could now answer this question: ✓+" (Teacher Edition, page 310).

***Suggestions for Improvement***

- Consider prompting the teacher to reference which student questions from the DQB are leading the lessons to improve navigation from the student perspective. Also, because a series of phenomena are used, student questions prompted at the beginning of the lessons will help students see the coherence in the unit from their perspective.
- Since the materials give direct guidance for students to have the opportunity to ask new questions in only seven out of the 17 total lessons (in these seven instances, students can revisit the DQB as well as ask new questions to add), consider adding prompts to support more opportunities in some of the 13 lessons where they do not.

# Why Do We See Patterns in the Sky and What Else is Out There That We Can't See?

EQuIP RUBRIC FOR SCIENCE EVALUATION

| I.E. MULTIPLE SCIENCE DOMAINS | |
|---|---|
| When appropriate, links are made across the science domains of life science, physical science and Earth and space science.<br>i. Disciplinary core ideas from different disciplines are used together to explain phenomena.<br>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*<br>*(None, Inadequate, Adequate, Extensive)* |

The reviewers found extensive evidence that links are made across the science domains when appropriate because students connect physical science and space science concepts. They learn about how the physical science concept of gravity affects the motion and relationships of solar bodies and thus create many phenomena that are visible to us on Earth. Students also explore light behavior concepts and how they affect space-related phenomena and how we see them. In addition, students are supported to explicitly make connections between CCC use in different scientific domains.

Related evidence includes:

- Students use the physical science concept of gravity to explain the behavior and patterns seen in solar bodies, involving the following DCIs:
  - **PS2.B: Types of Interactions**
    - *Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.*
  - **ESS1.B: Earth and the Solar System**
    - *The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.*
    - *This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.*
- Students use physical science concepts of light and its behavior to explain why we see eclipses and color changes and why we have seasons, involving the following DCIs:
  - **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.*
        - *A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.*
    - **ESS1.B: Earth and the Solar System**
        - *The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.*
        - *This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.*

CCCs are used across domains to make sense of phenomena. For example:

- Several CCC elements are used across both ESS and PS domains in the unit (see Criterion I.B).
- In addition to the focal CCCs, students have the opportunity to reference a **Cause and Effect** CCC element from a previous unit they were taught earlier in the year. "Explicitly make the connection here between cause and effect and the patterns in the sky students are investigating in this unit. Consider engaging students in making these connections by asking, How do cause-and-effect relationships relate to patterns? How could you use the cause-and-effect sentence frames that we used to explore the speaker to talk about patterns in the sky?" (Teacher Edition, page 18).

***Suggestions for Improvement***

N/A

| 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** | *Extensive* |

The reviewers found extensive evidence that the materials provide grade-appropriate connections to the Common Core State Standards (CCSS) in mathematics, English language arts (ELA), history, social studies, or technical standards. Students have the opportunity to read and engage with informational passages, infographics, websites, and podcasts. Students also regularly write, speak, and listen to advance and deepen learning. The materials provide a large amount of engagement with community, family, and historic connections to the science learning and phenomena under study. Students also use a small amount of mathematics in this unit.

Evidence related to ELA-Literacy use in the unit includes:

- Students engage in reading three to four passages in three different lessons. However, one is optional, and the lessons do not hinge on the reading aspects:
    - Lesson 4: Students read about the seasons to understand how we break them into patterns. "Defining Seasons" (Teacher Edition, pages 101–102).
    - Lesson 4: Students are provided with an optional extension reading about the Sun's apparent movement in the sky. "The Equator, the Midnight Sun, and the Analemma" (Teacher Edition, page 107).
    - Lesson 13: Students read about human observations from the past of Venus's patterns of motion. "Venus in Cultures Around the World" (Teacher Edition, page 244).
    - Lesson 16: Students read about the debate over what is in space that we can't clearly see. "The Great Debate" (Teacher Edition, page 295).
- When students are reading materials to explain phenomena, different formats of content are used. For example:
    - Lesson 2: Students listen to stories that Native Americans told about the Sun in the sky to make connections to their own experiences about the Sun. These stories are in a narrative format (Teacher Edition, page 60).
    - Lesson 3: Students read "Sun Patterns Over Many Hundreds of Years" and record measurements from the NOAA website to make sense of the Sun's pattern over the year (Teacher Edition, page 78).
- Students regularly write to explain and record in most, if not all, lessons. For example:
    - Lesson 4: Students record their ideas about seasonal patterns, the motion of the Earth around the Sun, and temperature in their progress checkers. Students clarify what they figured out and add their ideas (Teacher Edition, page 102).
    - Lesson 8: Students use their model of eclipses to figure out what they would see right before a lunar eclipse begins. Students then write down their explanation of the phenomena and record what they think would happen (Teacher Edition, page 167).
- Students extensively speak and listen during most, if not all lessons. For example, in Lesson 8: "CCSS.ELA-LITERACY.SL.8.1.C Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas. Students engage in speaking and listening with partners while they analyze images of lunar eclipses, compare those observations to what they predicted they would see, and suggest ideas for investigation. Students discuss ideas with the whole class when they share their ideas about potential model revisions, list related phenomena, consider possible causes, and collect their questions about color changes. In all of these situations, students should pose questions that

connect their ideas to a partner's ideas and/or to ideas shared by their classmates, as well as reference evidence from their models and observations from the lunar eclipse images. That said, the goal of this lesson is to generate questions rather than figure out specific answers to them—that work will continue through this lesson set" (Teacher Edition, page 175).

- Additional Teacher Guidance is provided that lists the CCSS.ELA standards and how they are applied in the lesson. For example, in Lesson 4: "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. In this lesson, students have multiple opportunities to read texts to find answers to some of their related questions (which will require them to determine central ideas in those texts) about seasons and the patterns of the Sun in the sky. When possible, students are encouraged to share what they've learned from the texts with their classmates and/or other trusted people (which gives them a chance to authentically summarize the text in order to support discussion about these ideas)" (Teacher Edition, page 108).

Evidence related to use of mathematics in the unit includes:

- Lesson 4: Students calculate the watts of solar energy per square inch. They add the number of watts per square and calculate an average to compare the data (Teacher Edition, page 99).
- Lesson 16: Students are given the context of powers of ten to think about scale, making explicit connections between mathematics and what they're learning in science: "Review the mathematical concept of powers of ten. Present slide E. Say, The movie we are about to watch uses a math idea to help zoom out and zoom in to different systems and objects in those systems at different scales by referring to something called powers of ten. Powers of ten are numbers that can be formed by multiplying any number by ten over and over again. For example, 2 multiplied by 10 is 20, multiplied by 10 again is 200, and multiplied again by 10 is 200. For very large numbers, powers of ten are sometimes represented by the number ten with an exponent. The exponent tells you how many times the ten is multiplied by itself to create the power of ten. Write this example on the board: 2 x 10 = 2,000,000,000 (two billion)" (Teacher Edition, page 296).
- Additional Teacher Guidance is provided that lists the CCSS Mathematics standards and how they are applied in the lesson. For example: "CCSS.MATH.CONTENT.7.RP.A.1 Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. For example, if a person walks 1/2 mile in each 1/4 hour, compute the unit rate as the complex fraction 1/2/1/4 miles per hour, equivalently 2 miles per hour. In this lesson, students calculate the ratio of light per unit area to solve a real-world problem: explaining temperature variation over a year" (Teacher Edition, page 108).

Evidence related to use of social studies in the unit includes:

- Lesson 1: Students gather and connect stories from family and community members about patterns in the sky they have seen or heard about and how these patterns connect to human life. These ideas from family are added to the Patterns and Phenomena in the Sky poster as shared resources.

- Lesson 2: Students watch two videos of Native American sky stories explaining why the North Star does not move.
- Lesson 6: Students view historic, cultural images of a Mayan moon calendar, Kohala Coast rock carving, and ancient Scottish calendar to understand that people have been observing lunar patterns over thousands of years.
- Lesson 13: Students read about the cultural connections people have made to Venus over time and the observations they made.

***Suggestions for Improvement***

Consider adding CCSS-ELA writing standards when significant writing tasks take place, such as when students create the comic strip or write out explanations.

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

# CATEGORY II

## NGSS INSTRUCTIONAL SUPPORTS

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

# Why Do We See Patterns in the Sky and What Else is Out There That We Can't See?

EQuIP RUBRIC FOR SCIENCE EVALUATION

## 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 | Extensive<br>*(None, Inadequate, Adequate, Extensive)* |
|---|---|

The reviewers found extensive evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world because all lessons provide students with the opportunity to experience the lesson level phenomena as directly as possible through videos, photos, simulations, and hands-on investigations. Also, numerous lessons provide students with the opportunity to engage their families, language, and culture as part of the class learning. Student questions from the DQB are connected to lesson learning leading to explanations.

Students experience the phenomena as directly as possible. For example:

- Lesson 1: Students view a video of Manhattanhenge.
- Lesson 2: Students view a video of a computer simulation showing the motion of solar objects over time.
- Lesson 3: Students view a video of a computer simulation showing the motion of the Sun over a year. Students create a physical model of the Earth-Sun system to experience the phenomenon.
- Lesson 5: Students make observations of the Moon at home to prepare for Lesson 6. Alternate Access to the Phenomenon. “If students can't see the Moon because it is not safe for them to make observations outside or because the sky is obscured by buildings or weather conditions, you can use this time to ask if any students have seen it in the past. You can also print out a lunar calendar from an online ephemeris such as https://www.timeanddate.com/ moon/ to provide for students. Students can check the phase of the Moon on their smartphones, if available, or using a search engine connected to the internet.”
- Lesson 7: Students watch a video of a solar eclipse.
- Lesson 8: Students view photos of a lunar eclipse in stages. “If you learned in preparation for Lesson 7 that any of your students will also opt out of viewing the lunar eclipse images in this lesson (because of their cultural beliefs about eclipses), you may problematize the idea of things

in the sky changing color with sunsets instead. Provide an image of a sunset such as those provided in the Lesson 9 slides to notice and wonder about, and proceed with the related phenomena gathering in part 4 of this lesson" (Teacher Edition, page 167).
- Lesson 9: Students observe photos of sunrises, sunsets, and moonrises.
- Lesson 11: Students view images of light-splitting phenomena. Students create rainbow images themselves.

Students are supported to connect instruction to their home, neighborhood, community, and culture. For example:

- Progress Trackers include a column titled, "How does this connect to or influence me or my community or other communities?" for students to formally name the connections.
- Lesson 1: Students gather and connect stories from family and community members about patterns in the sky they have seen or heard about and how these patterns connect to human life. These ideas from family are added to the Patterns and Phenomena in the Sky poster as shared resources.
- Lesson 2: Students watch two videos of Native American sky stories explaining why the North Star does not move.
- Lesson 5: "Share home learning observations of the Moon. Present slide A. As students come into class, collect their photos, stories, and/or drawings related to their observations of the Moon from Lesson 5 Community Guide for Looking at the Sky and display them around the room" (Teacher Edition, page 128).
- Lesson 6: "Present a home learning opportunity. Present slide J. Ask students to share the word for Moon in another language they are familiar with. Students can research the word for Moon in another language by speaking to their friends and family or by looking it up. Multilingual students may be ready to share right away. You may choose to have students record these words on sticky notes to add to a poster or in a shared digital document. Creating this space to share without judgement will honor in the classroom the knowledge brought by family and community, legitimize the resources emergent multilinguals bring to the classroom, and give emergent-multilingual students the opportunity to make content connections in their first language. Students may add other ideas, stories, and interpretations for these words" (Teacher Edition, page 132).
- Lesson 7: "While many people view eclipses as a cause for celebration, in some indigenous communities eclipses are seen as a bad omen or it may be taboo to look at videos or images of them… Be thoughtful about the students in your classroom, and if you believe viewing eclipses may be an issue for anyone, work with the student to identify alternatives to viewing eclipses that they feel comfortable with… While students might not feel comfortable viewing an eclipse, modeling one in subsequent activities may or may not require alternatives" (Teacher Edition, page 146).
- Lesson 13: Students read about the cultural connections people have made to Venus over time and the observations they made.

***Suggestions for Improvement***

N/A

| II.B. STUDENT IDEAS | |
|---|---|
| Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and respond to peer and teacher feedback orally and/or in written form as appropriate. | |
| **Rating for Criterion II.B. Student Ideas** | Adequate<br>*(None, Inadequate, Adequate, Extensive)* |

The reviewers found adequate evidence that the materials provide students with opportunities to both share their ideas and thinking and respond to feedback on their ideas because although students have extensive opportunities to express, clarify, justify, interpret, and represent their ideas and respond to peers in all lessons, direct guidance for formal student feedback is provided. However, peer feedback is provided only if time permits in one lesson or if the teacher happens to read the Assessment System Overview, where it is referred to generally. Formal teacher feedback on student work is not directly provided.

Students are supported to express, justify, clarify, interpret, and represent their ideas. For example:

- Students frequently work with partners and small groups to answer questions, complete tasks, model, and conduct investigations. For example, in Lesson 6, students are encouraged to use a physical model of the Sun-Earth-Moon model to demonstrate what they see at different views of the half-lit Moon. The teacher is given a list of questions to help students make sense of the model. The teacher asks what a person would see underneath the moon and why they would see it this way. Students justify their predictions based on their understanding of the Moon's counterclockwise movement and location relative to the Sun and observer (Teacher Edition, page 135).
- Students regularly engage in Scientist Circles for whole group sharing of independent ideas and models.
- Students regularly add their ideas and questions to a DQB and Phenomena in the Sky Poster.
- Students regularly develop individual, partner, and class consensus models together.

Direct guidance on using peer feedback in specific places in the unit is mostly optional. It is mentioned once if time permits in Lesson 12 and in the Assessment System Overview generally if the teacher chooses to use it in listed lessons. Also in Lesson 8, there is an opportunity for students to justify their models however, it is not explicit whether students revise their model based on the peer feedback they receive. Related evidence includes:

- In Lesson 8, "As partnerships finish organizing the images, pair them with another partnership to check each other's work. You may refer students to the Earth-Sun-Moon system models they've used in previous lessons to justify their decisions about the order of the images" (Teacher Edition, page 168). Note that there isn't evidence that students revise their work based on any feedback they get and that getting actual feedback versus just "right" and "wrong" isn't apparent.
- Lesson 12: "If time permits, you can have students use Peer Feedback Guidelines to provide on each other's models before bringing them together for the classroom consensus model. If you choose to do this, make sure to give enough time for groups to return to and revise their model (before moving on) and then you can have students reflect on how well they gave and received feedback today, using Peer Feedback Self Assessment" (Teacher Edition, page 231). Both of these documents are listed as Optional in the Lesson 12 Learning Plan Snapshot, so students might not have these feedback opportunities.
- Assessment System Overview (Teacher Edition, page 316):
  - "Peer Feedback: There will be times in your classroom when facilitating students to give each other will be very valuable for their three-dimensional learning and for learning to give and receive feedback from others. We suggest that peer review happen at least two times per unit. This document is designed to give you options for how to support this in your classroom. It also includes student-facing materials to support giving and receiving feedback along with self-assessment rubrics where students can reflect on their experience with the process."
  - "For this unit, Peer Feedback works best for Lessons 8, 10, 13, and 14 during the consensus moments where students are sharing their consensus models, or after an investigation where students share what they figured out with peers."
  - This guidance is very helpful, but references to it are not made in the lessons themselves, so teachers may not see or remember that there is an opportunity for peer feedback in the stated lesson locations.

Guidance related to teacher feedback is not provided in the unit. Related evidence includes:

- Teachers are given numerous prompts in all lessons on how they might respond to student verbal replies during class discourse. However, there does not seem to be direct feedback guidance or direction embedded in the lessons or assessments.
- Space Assessment System Overview: Direct identification and guidance for teachers to provide formative feedback to students is not given. "Strategically picking which LLPEs to assess and how to provide timely and informative feedback to students on their progress toward meeting these is left to the teacher's discretion" (Lesson by Lesson Assessment Opportunities, page 3).

***Suggestions for Improvement***

- Consider directly referencing and linking to the peer review guidance in the Assessment System Overview in the lessons themselves, or building in peer feedback opportunities within multiple lessons leveraging existing Peer Feedback Guidelines as part of lesson activities rather than being optional. Similarly, consider providing prompts within lessons for students to reflect on and respond to the peer feedback.

- Consider directly building in guidance within multiple lessons for teacher feedback to students as well as providing for opportunities for students to reflect on and respond to the feedback.

## 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.

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

The reviewers found extensive evidence that the materials identify and build on students' prior learning in all three dimensions. The Teacher Background Knowledge section provides information on what students are expected to have learned in earlier grades for all three dimensions. Guidance is also found in lessons to support teachers in knowing where students are likely to come in with skills and knowledge and where the lesson aims to take them.

The unit identifies expected prior student learning. Related evidence includes:

- The Teacher Background Knowledge section provides extensive information on what students should already have learned in the OpenSciEd units that come before this one in the sequence, including listing the PEs addressed (Teacher Edition, page 19).
- The Teacher Background Knowledge section provides information on the DCIs and SEPs students should have developed in the Elementary grades (Teacher Edition, page 19).
- The Teacher Background Knowledge section provides the CCCs from the 3–5 grade band that teachers should think about making sure students have familiarity with (Teacher Edition, page 19).
- The Teacher Background Knowledge section provides information on common ideas to expect from students (Teacher Edition, page 19).
- Lesson 1: CCC "Make sure when you are defining a pattern you do it in the language of your class, a pattern is a repeated instance. This is something that students should have coming in (from prior grade bands and OpenSciEd units), but because we are thinking on such different scales of time and size, it is important to make sure students acknowledge what these words

mean, especially if there are students new to the class and/or new to English" (Teacher Edition, page 32).

- Lesson 1: DCI "In grade four, students have developed a model to describe how light reflecting from objects and entering the eye allows objects to be seen (4-PS4-2). This model they reused and developed further in OpenSciEd Unit 6.1: Why do we sometimes see different things when looking at the same object? (One-way Mirror Unit). In particular, they developed the idea from PS4.B that the path that light travels can be traced as straight lines. You are trying to elicit these previously developed ideas, and you are also trying to make sure that the class agrees on these before moving on. This is an 8th grade unit, so it is important to surface these ideas to help ensure that all students in the class have an understanding that light travels in straight lines, can reflect off objects, and enter the eye (which results in seeing the object) before moving on and building off of these ideas by using models in service of explaining these patterns for more complex phenomena" (Teacher Edition, page 35).
- Lesson 2: DCI "Prior Knowledge: Students may know, from 5th grade, the movements of the Earth, Sun, and Moon and how these movements help describe the different positions of the Sun, Moon, and stars throughout the year. This lesson builds on that knowledge that the Earth is spinning but adds the idea that the Earth's axis is pointed toward a single star, Polaris, explaining why that lone star does not appear to move through the night, on any night of the year, and all the other stars visible in the sky (in the N. Hemisphere) appear to spin around it" (Teacher Edition, page 62).
- Lesson 3: DCI "Students should know or have identified in earlier grade bands that it takes the Earth one year to make a complete trip around the Sun. This lesson builds upon that knowledge to develop the idea that there are repeated, cyclical patterns of hours of daylight and the angle of the Sun at midday as the Earth orbits the Sun" (Teacher Edition, page 76).

The unit provides information about how students' prior learning be built upon. Related evidence includes:

- In the "Where we are going" sections before a lesson begins, if prior learning is going to be built upon, there is a description of the prior learning and how the lesson will expand on the learning. For example, in Lesson 2: "This entry point into thinking about seasonal patterns builds on first grade standards about the number of hours of daylight at different times of the year (1-ESS1-2) and the fifth-grade standards for explaining day and night using a model of the Sun and Earth and the rotation of Earth around it axis (5-ESS1-2)."
- "If your students have just finished OpenSciEd Unit 8.3 (Magnets), they have been thinking about the world in terms of cause and effect. Explicitly make the connection here between cause and effect and the patterns in the sky students are investigating in this unit. Consider engaging students in making these connections by asking, How do cause-and-effect relationships relate to patterns? How could you use the cause-and-effect sentence frames that we used to explore the speaker to talk about patterns in the sky? Students might suggest (or you might introduce) a modified sentence frame such as this…" (Teacher Edition, page 18).

- Lesson 4: CCC "In this lesson, students will use seasonal temperature data and distance from the Earth to the Sun during its orbit to identify patterns. This entry point into thinking about seasonal temperature patterns builds on third grade standards about typical weather conditions at different times of year (3-ESS2-2) and fifth grade standards for explaining day and night using a model of the Sun and Earth and the rotation of Earth around its axis (5-ESS1-2). Students then build a physical model tracing the Sun's path at different times of the year and use a flashlight to record data to pattern of changes in the amount of energy on Earth's surface and angle of elevation of the Sun in the sky. Students use these observations to explain the relationships between Earth's tilt, solar elevation, and seasonal temperature differences during Earth's orbit" (Teacher Edition, page 96).
- Lesson 10: In this example, prior learning is built upon from a previous unit. "In this lesson, students access specific prior knowledge they bring in from the OpenSciEd Unit 6.1: Why do we sometimes see different things when looking at the same object? (One-way Mirror Unit) that when light shines on an object, it can be reflected or transmitted. Students use this prior knowledge to consider what could be going on with light shining through Earth's atmosphere and the simulated atmosphere of milky water." It is described to the teacher what students will be entering with, how they will build on it in this lesson, and what conceptions they may have.

***Suggestions for Improvement***

- Consider providing statements for each lesson that describe the expected student proficiency for each of the targeted elements of the three dimensions (that weren't used in previous lessons in this unit) and how students are building on the elements from lesson to lesson.
- Consider providing information about how prior student learning will be built upon for all learning targets (including all SEP and CCC elements).

## II.D. SCIENTIFIC ACCURACY

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

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| **Rating for Criterion II.D. Scientific Accuracy** | Extensive |

The reviewers found extensive evidence that the materials use scientifically accurate and grade appropriate scientific information because all provided information is scientifically accurate, materials use phenomena that are appropriate for middle grade students, and discourse supports along with modeling examples are accurate. No inaccuracies were noted in the materials.

All scientific information, phenomena, and representations to support student three-dimensional learning are accurate. For example:

- Lesson 7: Students develop a physical model of the Earth-Sun-Moon system to figure out that they are seeing different views of a sunlit Moon when they observe Moon phases in the sky.
- Lesson 15: Students figure out that the solar system began from a collection of gas and dust particles going around the Sun drawn by gravity. Students figure this out through looking at images and obtaining information for videos and simulations (Teacher Edition, pages 285–287).

The unit provides an extensive Teacher Background section with information about lab safety and how the DCIs are used in the context of this unit. "Additional Guidance" sections throughout the Teacher Edition provide background information for the teacher that is accurate. "Where We Are Going and Not Going" sections provided in each lesson also deepen accurate teacher knowledge about the included science ideas.

***Suggestions for Improvement***

N/A

## II.E. DIFFERENTIATED INSTRUCTION

Provides guidance for teachers to support differentiated instruction by including:

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

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

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

| Rating for Criterion II.E. Differentiated Instruction | Extensive |
| --- | --- |

The reviewers found extensive evidence that the materials provide guidance for teachers to support differentiated instruction because all lessons provide direct guidance for teachers on how to support students in successful learning. This includes sidebars that provide suggestions on how to support students with specific SEPs, with Three-Dimensional Learning, and with UDL strategies for multiple modalities of learning access. Guidance is also provided within lessons for struggling students as well as extensions for students who are interested in going further.

The materials provide supportive ways to access instruction and alternates. Related evidence includes:

- Lesson 1: "Reminder about supporting students with visual disabilities: This unit uses images as data and phenomena that often include changes in light or color of an object in the sky. You will need to make accommodations so that students who are blind or have low vision can access this data. Depending on your students' needs, suggested modifications include enlarging and/or brightening the provided digital versions of these photos or using alternate text descriptions" (Teacher Edition, page 28).
- Lesson 1: Attending to Equity "Supporting emerging multilingual students: Scaffolds such as sentence starters can model and facilitate particular oral or written language production skills, such as formulating questions, hypotheses, explanations, or arguments based on evidence (see Communicating in Scientific Ways poster). Such scaffolds may be of particular benefit for emerging multilingual students to help them develop language skills to write or communicate their ideas to peers. It is important that scaffolds be used purposefully and removed when no longer needed" (Teacher Edition, page 46).
- Lesson 1: Attending to Equity "Universal Design for Learning: Use representations like color coding and/or letter or number coding to foreground parts of the model. Create a key to track what colors, symbols, or letter or number codes represent different parts of the system. While color coding is a useful way to quickly reference the parts of the model, letter or number coding helps ensure accessibility for any student who may be color blind. If color coding is used, consider a color palette that uses orange, blue, black, or dark brown" (Teacher Edition, page 46).
- Lesson 2: Attending to Equity "Supporting emergent multilinguals. It is important to organize activities in ways that create opportunities for students to engage in meaningful, accountable talk by emphasizing socially safe activity structures (e.g., small-group or partner work before a whole-class discussion). This is especially beneficial to multilingual students. For this reason, partner talk or small-group talk should precede whole-group discussion whenever possible to give students an opportunity to share their ideas with one or two peers before going public with the whole class" (Teacher Edition, page 59).
- Lesson 2: Attending to Equity "Supporting emergent multilinguals: Depending on the goals of a lesson or the goals for a particular aspect of a lesson, it is helpful to intentionally group emerging multilingual students with certain peers. Sometimes this could be peers who know the same languages as them, while other times it could be peers whose English language development is slightly more advanced. It is important that this grouping be thoughtful and that it varies throughout the course of a unit so that students benefit from working with different peers" (Teacher Edition, page 61).
- Lesson 3: "If students are overwhelmed by the amount of data presented on https://gml.noaa.gov/grad/solcalc/ and http s://gml.noaa.gov/grad/solcalc/azel.html, consider providing them a data set using data from NOAA websites" (Teacher Edition, page 79).

- Lesson 4: "This assessment encourages students to demonstrate their understanding of key skills and concepts from the unit so far through multiple modalities, including writing to explain and drawing models. Some students may benefit from using multiple modalities to show their thinking for any or all of the questions on this assessment. You may consider allowing some students to present their answers verbally with you or another student acting as a scribe to record their thinking on paper. Other students may benefit from using gestures rather than images to describe parts of their models. Some students might also benefit from using manipulatives to represent parts of the model and to support a written or verbal explanation of what's happening in each part of the model. In each case, encouraging students to use multiple modalities to show their thinking creates a clear, accessible, equitable pathway for all students to demonstrate proficiency" (Teacher Edition, page 107).
- Lesson 4: SUPPORTING STUDENTS IN THREE-DIMENSIONAL LEARNING "Lesson Set 1 (Lessons 1–7) is primarily focused on portions of the following performance expectation from the NGSS: MS-ESS1-1: Develop and use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons. This building understanding discussion is an opportunity to generalize across the patterns of the Sun we have described using models to help students see how the cyclic patterns of the Earth-Sun system can be explained using models. To make sure students see how the components and patterns identified in the Earth-Sun system and those identified in the performance expectation work together, highlight the role of orbit in our models using probing questions as students answer the discussion questions. When students describe the motions that explain the 20 min [sic] seasonal changes we see, push them to go further and explain the why of these changes: tilt and location of Earth in its orbit around the Sun. (Students are not expected to identify a specific shape associated with Earth's orbit around the Sun, only that it is not a perfect circle. In high school, students explore Kepler's Laws of Planetary Motion as a way to determine shapes of different orbits)" (Teacher Edition, page 99).
- Lesson 8: "If you have students who are color blind, this color-focused Lesson Set (Lessons 8–12) may pose a unique challenge. If you haven't already done so, take some time to talk with your student(s), familiarizing yourself with their way(s) of seeing the world and asking how you can best support them as they investigate why we see objects in the sky change color. Your students' IEP or 504 case leaders should also be able to provide you with specific resources and possible modifications to use" (Teacher Edition, page 166).

The materials provide extra support for struggling students. For example:

- Lesson 1: "SUPPORTING STUDENTS IN DEVELOPING AND USING SCALE, PROPORTION, AND QUANTITY The crosscutting concept of Scale, Proportion, and Quantity is central to this unit and to understanding space systems. Because our perspective on Earth is limited, phenomena that can be observed at one scale—for example by simulating the whole Solar System at once from a perspective above the system—may not be observable from our perspective. Many of the familiar patterns and phenomena we see on Earth are symptoms of this limitation of perspective and our inability to observe the system at scale. It is not until the fourth lesson set of the unit that we will define, as a class, what we mean by the Solar System. Review the unit front matter for an overview of how to scaffold crosscutting concepts in this unit" (Teacher Edition, page 34).

- Lesson 1: Additional Guidance "Note that while the scientific information in each of these podcasts is equally rigorous, they are written at various comprehension levels to support differentiation. The information in the least complex of the podcast is more concrete, while the others require more careful listening. The information in the most complex podcast is more abstract. You may choose to group students strategically so that students who need more support with obtaining information from scientific texts and listening comprehension are distributed among mixed-expertise groups assigned readings of mid-range complexity, while students who are looking for a challenge are in groups assigned podcasts at a higher complexity level" (Teacher Edition, page 39).
- Lesson 1: "SUPPORTING STUDENTS IN DEVELOPING AND USING SYSTEMS AND SYSTEM MODELS If needed, you could scaffold the idea of perspective further, by asking students to imagine what the Goldberg system might look like from another point of view, for example, that of the bird or that of the man. Consider using Systems Modeling Scaffold to lead a supplemental activity and discussion about this" (Teacher Edition, page 43).
- Lesson 2: "SUPPORTING STUDENTS IN ENGAGING IN ANALYZING AND INTERPRETING DATA Students often do not include enough details when recording data and observations. You can encourage them to do so by asking questions that include, I noticed you identified that the Sun is moving in the sky. Can you be more descriptive? We want to try to be able to build an idea of how specific objects appear to move. Or you can say, Do they all move in the same direction? I notice you wrote down the objects are all moving. Are all of these objects in the sky moving in the same way? By doing this, you will help all students understand how being specific in descriptions and observations will make it easier when they analyze and interpret the data to find similarities and differences and will result in the collected data serving as stronger evidence" (Teacher Edition, page 61).

The materials provide extensions for students with high interest or who have already met the performance expectations. However, these extensions mainly focus on DCI-related information. For example:

- Lesson 4: "Activity Extension opportunity: The Equator, the Midnight Sun, and the Analemma provides additional information to students that is not critical to their understanding of the DCIs in this unit, but is offered as a chance for interested students to dig a little deeper into the patterns people notice about the Sun's apparent movement in the sky. As such, students may choose to read just certain sections of the text that they find most intriguing. If students do not all get a chance to read this text, you might ask a few students to share with the class what they found out from reading in order to collect additional ideas on the Patterns and Phenomena in the Sky poster" (Teacher Edition, page 108).

- Lesson 6: "The orientation of the face of the Moon that we see due to tidal locking is beyond the scope of this lesson. However, if students are interested in this, they can explore the phenomenon of the orientation of the face of the Moon when using the online interactive in this lesson (guidance can be found in the lesson) and can explore the mechanism in a supplemental reading after Lesson 14" (Teacher Edition, page 127).
- Lesson 7: "Extension Opportunities: This lesson is focused on total solar eclipses, which are often referred to throughout the lesson as just eclipses. Additionally, students are asked to focus on what is happening in the path of totality, though this language is not used. If students want to explore partial solar eclipses or what it means to be in the path of totality, they will need to investigate the way that light travels and the structure of shadows created by a sphere (i.e., the umbra and penumbra). This can be done by pointing a light at a sheet of white paper and then using a sphere to cast a shadow onto the white sheet of paper" (Teacher Edition, page 151).
- Lesson 17: "Extension Opportunity: For an extension opportunity, if your students are interested in black holes, assign https://kids.nationalgeographic.com/space/article/black-holes as home learning. Ask students to consider as they read our question about what could be at the center of the Milky Way that is creating such strong gravitational force pairs to keep stars in orbit" (Teacher Edition, page 308).

***Suggestions for Improvement***

Consider providing extensions of SEPs and CCCs for students with high interest or who have already met the performance expectations.

## 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 | Extensive<br>*(None, Inadequate, Adequate, Extensive)* |
|---|---|

The reviewers found extensive evidence that the materials support teachers in facilitating coherent student learning experiences over time. All lessons include multiple and consistent supports to promote coherent learning, such as describing for teachers what students will figure out, describing where students are going, and using a DQB and a Progress Tracker across the unit.

The materials provide teacher guidance to support student engagement across lessons. For example:

- Every lesson begins with a "What Students will Figure Out" section.
- Every lesson begins with a previous lesson recap and a next lesson preview.
- Every lesson begins with a "Where we are going" and a "Where we are not going" section to support coherence.
- Students use lesson Progress Trackers to record their learning across time and what they figured out.
- Lesson 1: Students capture their questions on a DQB. "The DQB will be central to the sensemaking that happens in the unit. There are a variety of ways to set up the DQB depending on your classroom resources, use of technology, and the number of students you see each day. What works for some will not work for others. Most important is that the DQB is visible to students each day and represents "our shared mission." Students will be using the DQB to assess what they've figured out and identify next steps" (Teacher Edition, page 50).
- Lesson 1: "Develop ideas for investigations and data we need. Present slide Y. Ask, In order to start answering some of these questions, what investigations could we do and what data do we need?" (Teacher Edition, page 52)
- Lesson 2:
    - Intro: "Orient students to where we have been. Present slide A. Say, Last time we were together, we met with a trusted member of our community to examine patterns in the sky using Lesson 1 Community Guide for Looking at the Sky. What were some of the things you observed in the sky that we were interested in observing to figure out more about some of these patterns? Turn and talk with a partner" (Teacher Edition, page 59).
    - Questions: "Add new questions to the DQB. Display slide H and have students individually add more questions to the DQB. Say, Use the wonderings you had while watching the videos in class today to help create more questions to add to our DQB. Allow students a few minutes to record questions on sticky notes before moving into a scientists circle" (Teacher Edition, page 61).
    - Wrap Up: "Say, Next class, we will explore this further and see what we figure out and what limitations we encounter when trying to develop a three-dimensional model of the objects in this system that you drew today to explain why the changes we observed in sunlight over the course of a year happen" (Teacher Edition, page 65).
- Lesson 3:
    - Intro: "Think back to previous lessons. Remind students of the Sun stories we heard in the previous lessons. Present slide G. Say, Think back to the stories we have heard in the

previous lessons. What connections can you make between those stories and changes in the Sun during the year?" (Teacher Edition, page 78)

- Connections:
  - "Have the 'Patterns from the Sky' poster from Lesson 1 displayed. What connections can we make between the patterns in the collected data in this lesson to the patterns identified by other civilizations we studied in earlier lessons?"
  - "Look back at the model of the Earth–Sun–Moon system you made in Lesson 2, what sort of things would we need to make a physical model of that system in our own class?" (Teacher Edition, page 81)
- Wrap Up: "Say, It sounds like we have some results that suggest our models might need to be revised in order to account for the patterns we think we should see year after year. Let's plan to work on revising our models to better explain the patterns from our NOAA data tomorrow" (Teacher Edition, page 87).

- Lesson 4:
  - Intro: "Say, after we updated our Earth-Sun model to include tilt, we started identifying phenomena on Earth or activities that happen when the amount of sunlight changes. Did we think we could explain with tilt? What were some of those phenomena or activities that we thought could be explained with tilt? Let's look at the four dates we used to measure daylength and solar elevation. How would you describe the temperatures around those four dates?" (Teacher Edition, page 97)
  - Progress Tracker: "Record students' ideas in their Progress Trackers. Say, over the last few lessons we've developed some really important ideas about seasonal patterns, like the motion of Earth around the Sun and temperature, both of which impact a lot of people and other living things on Earth. Let's keep track of some of these ideas in the Progress Tracker in our notebooks."
  - Connections:
    - "Say, We've figured out a lot about the seasons we experience here, but have we heard about someone else's experiences in a different part of Earth? Look for students to point out that Jessie's podcast from Lesson 1 talked about different seasons in Australia. Lead a short discussion to explain the difference in these patterns in the Southern and Northern Hemispheres, and make a connection back to the podcasts in Lesson 1" (Teacher Edition, page 104).
    - "Can someone suggest an idea we've figured out about the Earth-Sun system from Lessons 1–4 that will help us explain why there are seasons and why those seasons are opposite in some places on Earth?"
  - Wrap Up: "Say, It sounds like we think that we can use what we have figured out about the seasons and the position of the Sun and Earth to explain other patterns in the sky. Let's try it and see if you can use our Gotta-Have-It Checklist to explain the Manhattanhenge phenomenon" (Teacher Edition, page 108).

Support is provided to link sense-making to learning in all three dimensions. For example:

- Lesson 4: "SUPPORTING STUDENTS IN THREE-DIMENSIONAL LEARNING Lesson Set 1 (Lessons 1–7) is primarily focused on portions of the following performance expectation from the NGSS: MS-ESS1-1: Develop and use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons. This building understanding discussion is an opportunity to generalize across the patterns of the Sun we have described using models to help students see how the cyclic patterns of the Earth-Sun system can be explained using models. To make sure students see how the components and patterns identified in the Earth-Sun system and those identified in the performance expectation work together, highlight the role of orbit in our models using probing questions as students answer the discussion questions. When students describe the motions that explain the 20 min [sic] seasonal changes we see, push them to go further and explain the why of these changes: tilt and location of Earth in its orbit around the Sun. (Students are not expected to identify a specific shape associated with Earth's orbit around the Sun, only that it is not a perfect circle. In high school, students explore Kepler's Laws of Planetary Motion as a way to determine shapes of different orbits.) Make this explicit for students by summarizing, Wow, we have identified a lot of patterns related to the Sun, and they all seemed very different at first! But by developing models of the Earth-Sun system in space, we were able to explain how tilt and orbit cause predictable changes in these systems and how those changes cause the seasons we experience and changes of the Sun we see in the sky" (Teacher Edition, page 99).
- Lesson 6: "SUPPORTING STUDENTS IN DEVELOPING AND USING SCALE, PROPORTION, AND QUANTITY. At this point in their figuring out, students do not need a scientifically accurate scale model of the Earth-Sun-Moon system. This lesson is about positioning those objects related to how the position affects the pattern or shape of the Moon we see. It is OK to foreground for students that considering scale is a great line of questioning that reminds us to figure out more about the size and scale of distance of these objects (and others) in our solar system. It also reminds us how important perspective is when we are modeling objects in the sky and space." (Teacher Edition, page 131)
- Lesson 6: "SUPPORTING STUDENTS IN ENGAGING IN DEVELOPING AND USING MODELS. Consider asking students whether they notice any limitations of the model used in this interactive. Because students have previously discussed the variation in the amount of daylight over the year due to location and the tilt of the Earth, they may notice that this model does not account for the tilt of the Earth or its orientation in relation to the Sun. These aspects of the Earth-Sun system are not necessary to figure out the phases of the Moon, so it is not necessary to represent them in this model. Model limitations will be further addressed in Lesson 7." (Teacher Edition, page 134)
- Lesson 13: "SUPPORTING STUDENTS IN THREE-DIMENSIONAL LEARNING. Three-dimensional learning is enhanced by connections to engineering, technology, and applications of science. Scientists use engineering advances to support the design of investigations to gather data about far away worlds. These infographics are an opportunity to highlight how advances in space

engineering have led to important discoveries about objects in our solar system" (Teacher Edition, page 253).

***Suggestions for Improvement***

N/A

## II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

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

| Rating for Criterion II.G. Scaffolded Differentiation Over Time | Adequate<br>*(None, Inadequate, Adequate, Extensive)* |
|---|---|

The reviewers found adequate evidence that the materials support teachers in helping students engage in the practices as needed and gradually adjust supports over time because scaffolds are seen to decrease over time for one SEPs element. However, scaffolds often remain the same over time, with class co-creations, class consensus, and small group work used consistently between lessons.

**Developing and Using Models:**

- *Develop and/or use a model to predict and/or describe phenomena.* New learning or progression of decreasing supports for this element over time was seen only in Lesson 6 when students physically model demonstrating their understanding of this SEP element.
  - Lesson 1: Students talk in small groups about the system parts that should be in their model. Students develop initial models to describe Manhattanhenge and show why the phenomenon happens on certain days but not others. They share and explain their model to other students (Teacher Edition, page 33). Later, students work in small groups to choose a sky pattern from a list identified by the class and think together about the parts of the causal system. Students then individually model to describe the phenomenon and interactions between the parts of the system involved. Students present their models in small groups (Teacher Edition, page 43).
  - Lesson 2: The teacher leads a discussion about sky patterns and how the patterns help us understand Earth-star interactions. Students develop initial models individually to describe the related system elements and their interactions that could explain how/why we see the motion of different objects in the sky including Earth, Sun, Moon, North Star, the patterns of motion, where someone is standing on Earth (Teacher Edition, page 63).

- Lesson 4: After conducting a light investigation and listening to a podcast that describes a different season pattern in Australia, students are asked to apply everything they have figured out so far to develop a Gotta-Have-It Checklist with a partner, hold a class discussion about the Gotta-Have-It Checklist, then develop a model individually to describe and explain seasons and why the seasons in Australia are the opposite of those in the U.S. (Teacher Edition, pages 105–107).
- Lesson 6: Students individually develop an initial model to describe and explain why we see the current phase of the Moon. Facilitated by the teacher, students co-create the list of elements that should be included to show interactions between them (Teacher Edition, page 130). Students work in small groups to explore with physically modeling the current Moon phase. Students work in their small groups to reach consensus on how to revise their initial models. They then use their physical model in their groups to predict the next phase of the Moon (Teacher Edition, page 132).
- Lesson 7: After viewing and discussing a solar eclipse video, students individually develop an initial model to describe and explain solar eclipses including the interactions happening with the objects in the system (Teacher Edition, pages 147–148). They then work in small groups to follow directions and build a physical model to further explore eclipses. Students co-create a class model and students modify their own initial models using the class model (Teacher Edition, pages 149–150).

- *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 co-create a consensus model that revises their model of Manhattanhenge from Lesson 1. "Develop a Gotta-Have-It Checklist to explain Manhattanhenge. Display the Parts & interactions in the system that help explain the Manhattanhenge Phenomenon poster from Lesson 1. Present slide F. Say, Let's look back at the parts and interactions in the system that we used previously to help explain the Manhattanhenge Phenomenon poster and consider what we might want to add to it or change in light of all that we have figured out about the Earth-Sun system over the previous few lessons. Tell students to turn and talk with a partner to evaluate what parts and interactions still work and what ones we need to change based on our new understandings" (Teacher Edition, page 116).
  - Lesson 9: Students co-revise their initial consensus model of the Earth-Sun system to add Earth's atmosphere and think about how it might be related to the color phenomena they have been exploring (Teacher Edition, page 187).
  - Lesson 11: Students explore how light reacts with differently shaped clear objects, some that hold water (Teacher Edition, page 213). They then co-create a model to show one of the scenarios they explored (Teacher Edition, page 214). Students then model individually to describe and explain one of the other scenario phenomena using a co-constructed Gotta-Have-It Checklist (Teacher Edition, page 217).

**Analyzing and Interpreting Data**

- *Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.* Some progression over time is seen for this element. Students work in large groups in Lesson 1, the teacher builds the demonstration model, and students make sense of the data together without an individual application. In Lesson 11, students work in small groups to collect data and after making sense in a group apply what they learned to a related phenomena and model an explanation individually. The level of support in lessons in between tends to stay on a similar level with students working in groups, making sense as a whole group, co-creating models or checklists with the data. Lesson 11 also tells the students how to collect the data, as in Lesson 3. Related evidence includes:
    - Lesson 3: Students measure and record patterns of change in the amount of daylight over a year and patterns of change in the angle of the Sun (Teacher Edition, page 75). They then collect data from NOAA to see patterns of change over thousands of years (Teacher Edition, page 78). Students share their pattern data and analyze it to discover that the Sun follows a stable, predictable pattern over hundreds of years (Teacher Edition, pages 80–81). "Teacher support: Students work in four groups and each group measures data for some of the months. Students measure data using a video. Data is shared in a scientist circle. The teacher builds a demonstration physical model and models it for the class to test and explore how the Sun and Earth system might interact to explain day and night and seasons. Students make sense of what they see together to explain" (Teacher Edition, pages 83–85).
    - Lesson 4: Students compare temperature differences in different locations on Earth and identify a pattern in temperature. "Teacher support—they do this in small groups with teacher walking around and assisting as needed" (Teacher Edition, page 98). They use a physical model to conduct a light investigation and discover that the angle of the light affects the solar energy reaching an area and its temperature. Students do this in groups of two to three and follow directions from a directions sheet. They calculate watts per square inch and then find an average. They discuss as a group. They listen to a podcast that describes a different seasonal pattern in Australia and then apply everything they have figured out so far to develop a Gotta-Have-It Checklist with a partner, then develop a model individually to describe and explain seasons and why the seasons in Australia are the opposite of those in the U.S. (Teacher Edition, page 105).
    - Lesson 10: Students work in groups to collect data as they investigate to see how light behaves as it shines through a medium (water with milk added). They make and record observations on color and brightness and use comparing words like more, less, brighter, and dimmer. The teacher rotates among groups to check student data collection. The data are shared in a scientist's circle and used to co-construct a model as a class about "how our atmosphere affects what we see and why objects in the sky appear to change color" (Teacher Edition, pages 199–200).

- Lesson 11: Students collect data in small groups as they investigate to see how light can split into different color bands. They are told how to collect the data by the teacher (Teacher Edition, page 212). They make and record observations such as rainbows, color patterns, etc. (Teacher Edition, page 213). They discuss the data with a partner, then in a scientist's circle to develop thinking about what happens to sunlight when it hits water droplets in Earth's atmosphere and how this can explain rainbows (Teacher Edition, page 214). Students then work independently to apply the thinking and model to explain a related phenomenon.

**Constructing Explanations**

- *Construct an explanation using models or representations.* No new learning or progression of reducing scaffolds for this element over time is seen.
  - Lesson 13: Students choose between two model representations of the Earth-Sun-Venus system and explains which one supports an explanation of all the patterns of Venus that people on Earth have noted over time (Handout: Competing Models of the Venus-Earth-Sun System). Students independently use manipulatives and drawings to explain where Venus and Earth would need to be located to explain four different visible phenomena (Handout: Explaining Venus Related Patterns) (Teacher Edition, page 250).
  - Lesson 17: Students work in groups of three to four to develop a model to explain why objects in space clump together with lots of empty space in between. They can reference a transcript with photos and a class poster. "We now know that other stars have rich systems as well, with planets and probably moons and other objects, but that there is a lot of empty space in between all these parts and systems. Why is it that we find things in space clumped together, with so much emptiness in between, instead of spreading out evenly? Can we make a model of the universe that shows and explains this structure?" (Teacher Edition, page 305)

***Suggestions for Improvement***

Consider mapping the progression of key SEP elements over time and building in gradual release of supports for students as the unit progresses so that students have increasing opportunities to apply the practice individually or more deeply. Another way that would make it helpful for teachers to support students over the course of the unit would be to include additional guidance in the side bar on how SEP elements will be scaffolded over time.

| OVERALL CATEGORY II SCORE: 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 | Extensive |
|---|---|

The reviewers found extensive evidence that the materials elicit direct, observable evidence of students using practices with core ideas and crosscutting concepts to make sense of phenomena or design solutions because students regularly engage in activities that result in direct, observable evidence or artifacts of student three-dimensional learning that is in service of sense-making around phenomena.

The unit elicits student artifacts in which students are using all three dimensions to demonstrate their learning. Related evidence includes:

- Throughout the unit (Lessons 3, 4, 7, 11, 12, and 13), students fill out a Progress Tracker to demonstrate their learning of what they have figured out over time. During this task, students construct explanations (SEP) using the DCIs that were figured out in the process of sense-making and applying related CCCs into their explanations. For example, in Lesson 13, students record new findings about other objects students see in the sky and new patterns to identify cause and effect relationships (CCC) they observed. They find out that inner objects are rocky and small while farther objects are large and gaseous (DCI).
- Lesson 1: Pre-Assessment: Lesson Objective "1.C Develop an initial model of systems in space to describe patterns we observe in the sky." Students create an initial model to explain the pattern-related phenomenon Manhattanhenge. The model shows patterns of motion in the Sun-Earth system and their relationships, as well as Earth's spin and orbit, that causes us to see this occur.
- Lesson 4: Formal Summative Assessment: Lesson Objective: "4.B Develop and use models of the Earth-Sun system to explain the cause-and-effect relationships between Earth's tilt, solar elevation, and sunlight energy on Earth's surface to explain seasonal temperature differences." Students complete the formal assessment, "What causes the seasons in Australia and why are they the opposite of our seasons." On the assessment, students are asked to model to show what causes seasonal variation between July and January. They are also asked to explain why the seasons are reversed in the U.S. and Australia. Both questions require students to explain the cause-and-effect relationship between seasons and Earth's tilt while the first question requires them to model to do so.
- Lesson 7: Formative Assessment. Lesson Level Objective: "7.A Develop and use a model of the Earth-Sun-Moon system to explain why and when we can see a solar eclipse." Students build

physical models in groups to show how the Earth, Sun, and Moon interact to cause an eclipse. After creating a class consensus model, students individually record learning in their Progress Tracker using words and/or pictures to answer the question "Why do we see eclipses and when do we see them?"

- Lesson 12: Formal Summative Assessment: Lesson Level Objective: "12.B Apply science ideas (selective reflection, absorption and transmission of different colors of light by different media and the refraction of light across different media) and evidence to provide an explanation for what causes the apparent color and location of some objects to change under water (effect)." Students model and write to explain what causes fishing lures to be visible to fish or not. They include a model that explains how the fishing lure phenomenon works and compare it to a similar effect in Earth's atmosphere. They also explain how color and brightness are affected as light passes through air as compared to water.
- Lesson 15: Students create a comic book storyboard which represents the formation of the solar system. Students use information obtained from media sources to support the claim they make (SEP) about the solar system being formed from a disk of gas and dust drawn together by gravity (DCI). Students display how the solar system looked chaotic once but has become more stable over time (CCC).
- Lesson 17: Unit Summative Performance Task: Lesson Level Objective: "17.A Develop a model of the universe that shows how gravity forces cause the patterns of motion and organization of objects in space systems at multiple scales." In the last lesson of the unit, students work in groups to create a final model of the universe. Students are directed to "Develop a complete model of how all these space systems fit together and help us organize make connections to life on Earth. Remember to use 'zooming' to represent multiple scales. Include the important parts of each system for considering where we might find life. Show how these systems are held together through interactions among the parts" (Lesson 17: Slides, Slide D).
- Progress Tracker: In Lessons 3, 4, 7, 11, 12, and 13 students record their ideas and explain what they have figured out using models, labels, and explanations. Students also revise their initial thinking and learning in the Progress Trackers as their understanding develops. For example, in Lesson 4, the learning objective for the lesson states "4.B Develop and use models of the Earth-Sun system to explain the cause-and-effect relationships between Earth's tilt, solar elevation, and sunlight energy on Earth's surface to explain seasonal temperature differences." After conducting an investigation to explore how the Sun's location in the sky affects solar temperatures on Earth and discussing the role of Earth's tilt in their Progress Tracker, students use any combination of words and pictures to answer the question "How do these changes in sunlight impact us here on Earth?" To do this, they model (SEP) showing the Sun-Earth system and how the Earth's tilt causes seasonal temperature differences related to solar elevation and sunlight energy (DCI and CCC). The CCC used in this lesson is: *Cause and effect relationships may be used to predict phenomena in natural or designed systems*.

***Suggestions for Improvement***

N/A

## III.B. FORMATIVE

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

| Rating for Criterion III.B. Formative | Extensive<br>*(None, Inadequate, Adequate, Extensive)* |
|---|---|

The reviewers found extensive evidence that the materials embed formative assessment processes throughout that evaluate student learning and inform instruction because each lesson provides identified formative assessment opportunities for the named lesson level objectives. There is some guidance in each case on what to look/listen for and what to do, the formative assessment support include specifics for each of the three dimensions, and the "what to do section" is aimed at supporting the student to complete the assessment task and provides specific guidance for teachers to modify instruction based on student formative assessment. However, the formative assessments do not provide sample student responses showing a range of understanding that would support teachers to provide feedback and adjust instruction.

Formative assessment opportunities are directly identified in every lesson. For example:

- Lesson 2: Students develop initial models to explain pattern motions of the Sun and Moon.
- Lesson 3: Students model in their Progress Trackers to explain the apparent path of the Sun across a year and changes in the length of days.
- Lesson 4: Students work as a class to develop a Gotta-Have-It Checklist that includes the tilt of the Earth on its axis and daylight hours to explain seasons.
- Lesson 5: Students model to explain how the tilt of the Earth and its orbit causes Manhattanhenge.
- Lesson 6: Students model to predict the next phase of the Moon and explain why.
- Lesson 7: Students use physical models to explain how a person's location on Earth and the Moon's position affects what they see related to solar eclipses.
- Lesson 8: Students observe images and compare them to the model they created to predict lunar eclipses. They then identify the limitations of their model.
- Lesson 9: Students discuss how a model might help explain causes for color changes in the Sun at sunset.
- Lesson 10: Students conduct an investigation and discuss their results to understand the changes in color and brightness of light shining through Earth's atmosphere.

Suggestions are provided in several lessons that provide general guidance to teachers on how to adjust instruction based on student responses during formative assessments. Several examples are noted below:

- Lesson 5: "If students do not identify that there is symmetry in the patterns of the day length or solar elevation as a result of fixed tilt and orbit of the Earth, have them add details to their Progress Trackers or Modeling Sunlight Angles from Lesson 4 to practice working with these ideas. If students do not identify changes in the location of sunrise or sunset as a result of these patterns, refer them to look again at Modeling the Earth–Sun System from Lesson 3, perhaps even recreating and manipulating that model again. You might also have them use their models to explain patterns in a series of local sunrise, sunset, and/or sun path images or video from the same location over the course of a year" (Teacher Edition, Page 144).
- Lesson 11: "Prior to Day 2, observe student understandings by reading or collecting their responses to the reflection questions on Rainbow Lab Instructions and Data Collection to check for understanding of patterns; use these responses to inform which students or groups you check in with more frequently for support on Day 2" (Teacher Edition, Page 234).
- Lesson 11: "If students are struggling to answer the prompts above, take time to set up some of the materials from Day 1 again, such as the prism, and talk with them through the modeling while they manipulate the physical materials" (Teacher Edition, page 239).
- Lesson 12: "For students who may still have gaps in their understandings or use of practices, consider having them retry their work on the assessment while resetting and reusing the physical materials they used for investigations in this lesson set as a reteaching opportunity" (Teacher Edition, page 254).
- Lessons 4: An alignment table is provided to assist teachers in formatively assessing students in all three dimensions.

Instruction is informed after each formative assessment. For example, in Lesson 16, the assessment opportunity has students discuss their ideas about space systems in our universe and think about the universe on a galactic scale. There is direction provided to teachers indicating what to look for and what to do during the assessment. Teachers are guided in supporting students who are struggling. For example, on page 144, "What to do: If students do not identify that there is symmetry in the patterns of the day length or solar elevation as a result of fixed tilt and orbit of the Earth, have them add details to their Progress Trackers or Modeling Sunlight Angles from Lesson 4 to practice working with these ideas. If students do not identify changes in the location of sunrise or sunset as a result of these patterns, refer them to look again at Modeling the Earth– Sun System from Lesson 3, perhaps even recreating and manipulating that model again. You might also have them use their models to explain patterns in a series of local sunrise, sunset, and/or sun path images or video from the same location over the course of a year." This teacher direction is three dimensional using the CCC of patterns, the SEP modeling, and the DCI of the Earth-Sun-system to guide teachers on how to correct models using local patterns of the sunrise and sunset, to assist them in using their models

***Suggestions for Improvement***

- Consider specifically acknowledging supports for each dimension (e.g., color coating, providing guidance in rubrics or scoring guidance) so teachers know which dimension students are struggling with or need support in.
- Consider providing teacher support in formative assessments focused on other dimensions besides supporting students who need assistance in understanding the DCI.

## 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** | Extensive |

The reviewers found extensive evidence that the materials include aligned rubrics and scoring guidelines that help the teacher interpret student performance for all three dimensions. Assessment targets along with scoring guidance is provided for formal and summative assessments. However, scoring guidance is not provided beyond exemplar responses. Additionally, tools are provided to allow the teacher to gather enough information to inform modification of instruction or targeted feedback, and formal assessment scoring guidance includes direction related to middle school-level CCCs.

Related evidence includes:

- Lesson 4: An answer key is provided using a "+" and "++" coding system to mark key ideas that students should include in their work. It's stated if students earn more "++"that "this may indicate they have mastered the science ideas" and vice versa. A three-dimensional alignment table is also provided that provides "possible evidence that the element is used effectively in the student's explanation."
- Lesson 12: In addition to an answer key and alignment table, teachers are provided with a rubric broken down by dimension. This rubric also allows teachers to assess the student as "missing, developing, or mastered" for the specific element. It does not provide sample responses that would indicate what a missing, developed, or mastered response would include.
- Lesson 17: For the summative assessment, an alignment table and a rubric are provided similar to those in lesson 12.
- Students track their thinking over time through their progress tracker so teachers can interpret student understanding throughout the unit (lessons 1, 3, 4, 5, 7, 11, 12, and 13).
- Lesson 4 and Lesson 12: Answer keys are provided for the Lesson 4 and Lesson 12 summative assessments (Teacher Edition, page 357, Teacher Edition, page 385). The key uses a "+" and "++" coding system to mark key ideas that students should include in their work. Alignment tables are provided to indicate the three-dimensional performance expectation, the descriptors for each

element, and what students must do to demonstrate learning in each dimension. For example, in lesson 12, students must, "Apply science ideas (selective reflection, absorption and transmission of different colors of light by different media and the refraction of light across media) and evidence to provide an explanation for what cause the apparent color and location of some objects to chance under water (effect). In order to do so on the assessment, students demonstrate understanding of the SEP by using a model to explain how the medium that light passes through can selectively absorb and transmit different amounts of different colors. Students demonstrate understanding of the DCI when they use ideas about selective reflection, absorption and transmission of different colors of light by different media to explain why some colors of fishing lures are more easily visible underwater, Students demonstrate understanding of the CCC when students make predictions about the effects (why it could be harder to see some colors under water compared to others and whether a fish's apparent position might change in different water depths) caused by the differences in absorption, transmission and the refraction of differences in absorption, transmission, and reflection of light in different media. In addition, scoring guidance is provided with who to interpret a student response. "Formative assessment opportunities are called out within the lessons. In these opportunities, the lesson level PE is named, and teachers are told generally what to look/listen for and what to do if students are struggling. Interpretive scoring guidance is provided indicating what teachers can do in order to support students who are struggling. However, no scoring or interpretative guidance is given to help teachers interpret a variety of student responses.

- Assessment Overview Document: Assessment opportunities for every lesson are described in the Lesson-by-Lesson Assessment Opportunities section (Teacher Edition, page 3). Here, assessment guidance is provided for each of the lesson level PEs consisting of "When to check for understanding" and "What to look/listen for," which describe only exemplar student responses, not a range of student responses. No scoring or interpretative guidance is given. For example:
    - Lesson 1 (page 4): 1.A **Asking Questions; Patterns**
        - **"When to check for understanding**: Day 1 - Notice the kinds of patterns students come up with as they begin to build the 'Patterns and Phenomena in the Sky Poster' on Day 1. Day 4 - Take note as the class builds the DQB on Day 4".
        - **"What to look/listen for**: Day 1 - Use this as a pre-assessment to gauge how much your students already know about space. Listen for students to list observable phenomena connected to not only the motion of objects in the sky/space but also their appearance. Objects may include the Sun, Moon, stars, and planets. Some students may be suggesting comets and galaxies, while other students might suggest that the Sun goes around the Earth. Day 4 - As the class builds the Driving Question Board, listen for: (1) the subsystems, patterns, and changes in objects that students are asking questions about; and (2) how the questions relate to patterns and systems. Possible systems/subsystems could include the Earth–Sun, Earth–Moon, Earth–Sun–Moon, other objects in the Solar System, color changes of objects such as planets/moons/suns/stars/galaxies, shape changes (or eclipses/transits) or visibility changes for these different objects."

***Suggestions for Improvement***

- Consider providing teachers with a range of student responses and interpretation guidance related to the full range of student responses in each of the three dimensions.
- Consider adding more rubrics like in lessons 12 and 17 but provide examples of what each level of response may include.

## 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 |
|---|---|

The reviewers found extensive evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples because the assessment opportunities use clear and accessible language and representations, and students regularly have the opportunity to use different modalities to show their understanding.

Related evidence includes:

- Lesson 1:  Students talk in groups and record ideas on post-its (Teacher Edition, page 37).
- Lesson 2: Students create a model to show their understanding (Teacher Edition, page 44).
- Lesson 4: Students can use physical modeling supplies from earlier lessons (Teacher Edition, page 107).
- Lesson 4: In the What Causes the Seasons Summative Assessment, students are provided photographs showing a wombat and butterfly. Vocabulary used in the assessment is accessible. Students use a provided model template to explain and information is provided in simple tables. Sections of the assessment are spread out with plenty of working space.
- Lesson 7: Students physically model a solar eclipse in groups (Teacher Edition, page 149).
- Lesson 12: Explaining Fishing Related-Phenomena Summative Assessment: The assessment is broken into parts with open space between. Lines are provided to support writing. Photos are provided to support understanding. Gradual release is built in with Part 1 being completed as a class, Steps 2–5 being completed with a partner, and Steps 6–7 completed individually. Steps 6 and 7 offer students the choice of using "words and/or pictures" to show and explain.
- Students are often scaffolded in modeling assessment tasks so they can successfully show their understanding. Related evidence includes:

- In multiple lessons, students have the opportunity to first help develop a class consensus model and then to go on and develop a related model individually that is used for assessment.
- In multiple lessons, students have the opportunity to co-develop a Gotta-Have-It Checklist that scaffolds students to include the needed parts of the assessment model.

Multiple modalities can be and are encouraged during tasks. For example:

- Lesson 4: While students figure out ideas to help them understand phenomena, they record their ideas in a Progress Tracker. Students can record their ideas using words, pictures, or both to show their thinking. "Students should label the left side of the T-chart 'Question/Lesson #' and the right side 'What I figured out,' as shown on the slide. Direct students to record the lesson question in the left column of the table, along with the lesson number. Then have students add their ideas in the right column. Remind them that they can use any combination of words and pictures to record their ideas. An example of what students might record is shown in the next table" (Teacher Edition, page 102).
- Lesson 12: During a summative assessment task, teacher directions explain that students may benefit from using multiple modalities to show their thinking for any question on the assessment. Students may even present their thinking verbally while the teacher or another student records their thinking. Some students may use gestures, images, modeling, or writing to show their thinking (Teacher Edition, page 235).

***Suggestions for Improvement***

N/A

## 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* |

The reviewers found adequate evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning. Pre-, formative, and summative assessments are directly provided for in the materials, and self-assessment is offered as an optional method if time permits.

Related evidence includes:

- Student work in Lesson 1 is identified in the assessment system overview as pre-assessment through the initial Manhattanhenge phenomena and patterns discussions, and DQB development.
- All lessons include identified formative assessment opportunities for the lesson level objectives.
- Lessons 4, 12, and 17 provide summative assessment opportunities.
- Student work in the Progress Tracker occurs as assessment artifacts in several lessons.
- Self-Assessment is identified in the Assessment System Overview. Guidance states, "Choose to use this at least once a week or once every other week." However, in the two lessons in which it is directly included, it is stated as being optional — to be used if time permits. Therefore, there is no evidence that self-assessment would actually occur as part of the unit assessment system.
    - Lesson 5: "Discussion Self-Assessment. If time permits, distribute Self-Assessment for Classroom Discussions to students and have them fill it out on their own" (Teacher Edition, page 119).
    - Lesson 9: "Discussion Self-Assessment. If time permits, distribute Self-Assessment for Classroom Discussions to students and have them fill it out on their own" (Teacher Edition, page 160).

Pre-, formative, and summative assessments are connected to three-dimensional learning goals. For example:

- Space Assessment System Overview: In this document, it is indicated in which lessons assessments will take place, which types of assessments they are, which elements of each dimension will be assessed, and when in the lesson they will be assessed.
    - Lesson 1 has the following lesson level learning targets that assess all three dimensions: "Building toward 1.A. Ask questions about systems in space that arise from observations of patterns in the sky. This is a considered a pre-assessment to get an understanding of how much students already know about space" (Teacher Edition, page 4).
    - Lesson 5 has the following lesson level learning targets that assess all three dimensions: "5.A Develop and use a model of the Earth-Sun system to explain how Earth's fixed tilt and orbit would cause a cyclical pattern in the location of the Sun as sunset that repeats every year" (Teacher Edition, page 5). This is a formative assessment.
    - Lesson 17 has the following lesson level learning targets that assess all three dimensions: "Develop a model of the universe that shows how gravity forces cause the patterns of motion and organization of objects in space systems at multiple scales." This is a summative assessment.

The Assessment System Overview details how each assessment is connected to a three-dimensional lesson goal. Students apply grade-appropriate elements of the three dimensions to explain the unit and related phenomena. Also, within the Assessment System Overview, there is a description and rationale for each assessment. For example:

- Assessment System Overview: Lesson 4: "There is a summative assessment early in this unit because there are several key ideas around seasonal temperature variation that we will not revisit in the unit. This assessment asks students to use their Gotta-Have-It Checklists, seasonal temperature variation data in the assessment, and a model to explain what causes the varied temperatures (effect in different seasons in Australia like we heard about in the podcasts. The assessment also asks students to explain seasons and temperature variation by comparing the northern and southern hemispheres" (Teacher Edition, page 1).
- Assessment System Overview: Lessons 7 and 8: "In this assessment opportunity, students work in groups to develop a Earth-Sun-Moon system model to explain when and why we can see a solar eclipse, with their groups. During the modeling, students should use their physical models to communicate about the relationship of where an observer is on Earth and the Moon's position relative to the Sun and Earth so that the observer would see a solar eclipse. Students will also have an opportunity to reflect on their use of different models to compare the purpose of each model and identify the boundaries and limitations of each. Students identify the purpose of using both physical and drawn models — including different perspectives — and their various limitations. If time permits, students can complete Lesson 7: Self-Assessment for Collaborative Group Work as part of their reflection. At the beginning of Lesson 8, students use the classroom consensus model to develop an individual prediction for lunar eclipses in their notebooks which they return to reflect on what they model did and did not correctly predict on Analyzing Lunar Eclipse Images."

***Suggestions for Improvement***

- Consider building in direct supports within the lessons for student self-assessment to occur.
- Consider aligning all assessments to three-dimensional learning goals.

## 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 |

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 because students are able to regularly show their growth in understanding within lessons through iterative modeling activities and through Progress Tracker work. However, direct opportunities for students to receive formal feedback from peers and the teacher and to revise work based on the formal feedback are not included in the lessons.

Related evidence includes:

- Progress Tracker: In Lessons 3, 4, 7, 11, 12, and 13 students record their ideas and explain what they have figured out using models, labels, and explanations. Student also revise initial thinking and learning in the Progress Trackers as their understanding develops.
- Lesson 1: Students develop an initial model of Manhattanhenge that is revisited and revised in Lesson 5 based on the learning that occurred in between.
- In Lessons 2, 3, 4 and 5, students have opportunities to demonstrate increasingly more developed ideas about the Earth-Sun-Moon system and its relationship interactions:
    - Lesson 2: Students model to explain why we see the North Star not appearing to move in the sky although other stars look like they are moving.
    - Lesson 3: Students model to explain how Sun-Earth interactions relate to the amount of daylight and the Sun's apparent path over a year.
    - Lesson 4: Students show understanding on a summative assessment of how Sun-Earth interactions cause seasons.
    - Lesson 5: Students model to explain Manhattanhenge.

Peer feedback is mostly optional in this unit. For example:

- In Lesson 12, "If time permits, you can have students use Peer Feedback Guidelines to provide feedback on each other's models before bringing them together for the classroom consensus model. If you choose to do this, make sure to give enough time for groups to return to and revise their model (before moving on) and then you can have students reflect on how well they gave and received feedback today, using Peer Feedback Self Assessment" (Teacher Edition, page 231).
- In the Assessment System Overview, "there will be times in your classroom when facilitating students to give each other feedback will be very valuable for their three-dimensional learning and for learning to give and receive feedback from others. We suggest that peer review happen at least two times per unit. This document is designed to give you options for how to support this in your classroom" (Teacher Edition, page 316).
- In Lesson 8, "As partnerships finish organizing the images, pair them with another partnership to check each other's work. You may refer students to the Earth-Sun-Moon system models they've used in previous lessons to justify their decisions about the order of the images" (Teacher Edition, page 168).

***Suggestions for Improvement***

Consider building in and identifying direct and regular opportunities for students to receive formal oral and written feedback from peers and the teacher and then to revise their work based on the feedback. Here are some sources that describe ways to provide feedback to students:

- https://pdo.ascd.org/lmscourses/PD13OC005/media/FormativeAssessmentandCCSwithELALiteracyMod_3-Reading2.pdf
- https://www.nextgenscience.org/sites/default/files/EQuIPDetailedGuidanceMarch2021.pdf

| OVERALL CATEGORY III SCORE: 2 | |
|---|---|
| **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 |

# Why Do We See Patterns in the Sky and What Else is Out There That We Can't See?

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) |