EQuIP RUBRIC FOR SCIENCE EVALUATION

Discovering New Worlds

DEVELOPER: New Visions For Public Schools

GRADE: High School **|** **DATE OF REVIEW:** November 2021

Educators Evaluating Quality Instructional Products

Discovering New Worlds

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 NextGenScience using the EQuIP Rubric for Science.

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

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Summary Comments

Thank you for your commitment to students and their science education. NextGenScience is glad to partner with you in this continuous improvement process. The unit is strong in many areas, including engaging students in three-dimensional learning that focuses on real-world phenomena and a driving problem. In addition, students are consistently supported to share and reflect on their ideas, and extensive supports are provided to help students connect their learning coherently over time.

During revisions or use in the classroom, the reviewers recommend paying close attention to the following focus areas to strengthen materials:

- **Teacher feedback.** Consider including opportunities throughout the unit for students to receive written and oral feedback from teachers and use the feedback to improve their performance.
- **Matching assessment targets and scoring guidance for Science and Engineering Practices (SEPs) and Crosscutting Concepts (CCCs).** Consider ensuring that scoring guidance closely matches assessment claims for all three dimensions.
- **Explicit use of grade level-appropriate CCC elements.** Consider more often including explicit support for students to understand how specific high school-level CCC elements can be useful in multiple different scientific disciplines. Currently, these connections are more often made with CCC categories that are not grade specific, e.g., "Patterns."

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 WAS met; the purple text is simply not part of the argument for that Extensive rating.

Unless otherwise specified, page numbers in this review refer to the PDF pages in following documents: TG = Teacher Guide, TM = Teacher Materials, SM = Student Materials.

CATEGORY I

NGSS 3D DESIGN

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

I.B. THREE DIMENSIONS

I.C. INTEGRATING THE THREE DIMENSIONS

I.D. UNIT COHERENCE

I.E. MULTIPLE SCIENCE DOMAINS

I.F. MATH AND ELA

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

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

i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving.

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

iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.

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

The reviewers found extensive evidence that learning is driven by students making sense of phenomena because learning is driven by students figuring out an anchor phenomenon, investigative phenomena, and completing a design challenge related to a problem to solve. The anchor phenomenon and design problem provide a consistent focus throughout the unit and there are opportunities for students to return to the phenomena to add layers of explanation. Students also have many opportunities to feel as if they are driving learning, although there are also many times where the learning is teacher driven.

Although much of the unit focuses on students finding solutions to a problem, almost all the learning is focused on science ideas (rather than both engineering and science ideas). The phenomena and problems used in the unit match the targeted scope of student learning. The evidence listed under Criterion I.B features the targeted DCI elements of the three dimensions that are identified in the unit materials that help students explain the unit phenomenon of why Earth is a planet that can sustain life and the design challenge of finding an exoplanet that could be habitable.

The focus of instruction is making sense of phenomena and solving a problem. Students return to the phenomena and problem to add layers of explanation or iterate on solutions based on learning at the beginning (Engage) and end (Evaluate) of each 5E Instructional Sequence. Related evidence includes:

- The Anchor Phenomenon is listed as “Earth is an Ideal Place to Support Life” (TG, page 21). This phenomenon is connected to a “phenomenon question:” “Out of all the planets in the Solar System, what makes Earth able to sustain life?” (TG, page 21).
- The Anchor Phenomenon is connected to a problem that is used to drive learning in the unit: “A rise in global average temperatures is making Earth less and less habitable!” (TM, page 17).
- 5E1: How the Sun Works: An Investigative Phenomenon is identified for this 5E sequence: “Energy released by the Sun in one second is more energy than the entire world uses in a whole day” (TM, page 32).

- 5E2: Star Life Cycles: An Investigative Phenomenon is identified for this 5E sequence: "Historical records from all over the world describe the explosion of a star in 1054" (TM, page 78).
- 5E3: Planets and Orbits: An Investigative Phenomenon is identified for this 5E sequence: "Comet Borrelly has water that is frozen most of the time, but every several years it shoots out a jet of vaporized water and dust" (TM, page 134).
- There are frequent references back to the anchor problem, connecting it to the focus question of the current investigation. For example:
    - 5E1: "Ask students to share their current thinking about what we are trying to figure out (Does the exoplanet have a Sun like ours?). 2) Tell students that, so far, many ideas have surfaced about what our Sun is like and how it releases energy" (TM, page 45).
    - 5E1: At the end of the instructional sequence (evaluate) students revisit the anchor phenomenon and reflect on how their new learning about the sun (investigative phenomenon) has helped them understand why Earth is a planet that can sustain life (TM, pages 63–68).
    - 5E2: "Remind students that they are looking for a star that lives long enough and provides stable enough conditions for water to exist in liquid form, sustaining life on its planets" (TM, page 80).
    - 5E2: "What are your overall takeaways from the star in the box simulation? Consider what you know about the conditions that are necessary for humans to live on a planet and how much time it takes for life to evolve, then decide which group of stars are most likely to support a planet that sustains life" (TM, page 90).
    - 5E2: "Have students revisit the life on Earth time scale from the Anchor Phenomenon and respond to the following questions independently: What do we need to know about other stars to determine if they are as stable as our Sun? What are the factors that contribute to a planet's stability for supporting life?" (TM, page 113).
    - 5E3: The teacher is told to say, "We are going to use a Class Consensus Discussion, just like we did a few days ago, to learn about all the thinking in the room and come to some decisions about what our mathematical model has helped us figure out about the orbit, and the potential for water, on exoplanets in our data set" (TM, page 157).
    - 5E3: After investigating orbiting objects students return to models and explanations created in the unit launch (performance task organizer) to revise and add their new learning (TM, pages 166–168).

Student questions and prior ideas drive much of the learning in the unit. Materials provide structured support for teachers to draw out student questions and prior learning to use these connections to motivate student learning when each new investigative phenomenon is introduced. Students have frequent opportunities to feel as if they are driving the learning sequence, although some of the learning is teacher driven. Related evidence includes:

- The Teacher Guide indicates that driving questions should be given to the students rather than coming from the students: "Aims for the lesson can be reworded to be more student-friendly by stating the question that students need to be able to answer by the end of a class period or 5E instructional sequence… For example, instead of asking How does the nuclear fusion of hydrogen generate energy in the Sun?, a teacher could ask How does Sun release so much light and heat?" (TG, page 17). During the Anchor Phenomenon Launch, the teacher is told: "transition to the next step by saying: "Out of all the planets in the solar system, Earth has life! Earth didn't have life for a long time and now it does. So what is it about Earth that makes it the only planet in our solar system that has sustained life?" (TM, page 12). Therefore, the teacher asks the question about the anchor phenomenon, rather than facilitating students to ask questions. Similarly, the Performance Task is introduced by telling students to answer this question that was given to them before students have a chance to wonder about this themselves: "Your task for this unit is to investigate what has made Earth the only planet in our solar system that can sustain life" (e.g., TM, page 17).

- Teachers are given a suggestion to involve students in figuring out what they need to learn: "One suggestion we have seen is to co-construct daily objectives with students (ask, given what we are trying to figure out, how will we do this?)" (TG, page 17).
- The teacher is told "It is likely that some student ideas will be inaccurate or incomplete, but the teacher should not confirm or invalidate students' ideas during the unit. Instead the teacher should use student ideas to inform instructional next steps in the moment or within the 5E sequences that follow" (TG, page 25).
- "Throughout and at the end of each 5E sequence, students revisit the DQB and determine which questions have been answered, what still needs to be figured out, and are given the opportunity to add new questions that arise as a result of their learning" (TG, page 26).
- Unit Launch: "During the Driving Question Board routine, student questions related to the Sun will emerge, based on their initial models of what makes Earth habitable. Once a category related to these questions has been articulated (e.g., questions related to 'Does the exoplanet have a star like our Sun?'), let students know that over the next few class periods, they will begin investigating this question to figure out what is so special about our Sun and how it gives us the right amount of energy for life to exist" (TM, page 2).
- Unit Launch: "Transition to the next step by saying: 'While Earth has been habitable for a long time now, scientists are concerned about the stresses Earth has been experiencing in recent decades and what it means in terms of its capacity to sustain life as we know it in the future.' Tell students that you are going to show a video and provide three texts that the class can use to collaboratively tell the story of what is currently happening to planet Earth" (TM, page 12). The class activities shift away from using student ideas to drive instruction; the teacher changes the subject (from the students' perspectives) without facilitating students to be curious about the new subject area.
- Unit Launch: "Students are likely to name a range of possible solutions, including finding another planet or moon for humans to live on. The solution of finding another planet will be the focus of the performance task that drives instruction in the unit. If students do not name this solution, tell them that this is one solution that scientists are exploring, just in case we cannot ensure the survival of the human species here on Earth" (TM, page 16). "Let them know that in this unit they will have the opportunity to explore one of their proposed solutions, finding another Earth-like planet for humans to live on" (TM, page 17).

- Unit Launch: "Tell students you're going to show them a video that will give them some information about planets that are out there for them to investigate. Show the first two minutes and fifty seconds of the How many Planets? Video" (TM, page 17). This activity is done before students ask any questions or show any motivation to learn about other planets.
- Unit Launch: "What do we need to investigate in order to find an Earth-like planet where humans and other species might be able to live? Think about your initial explanations for why planet Earth is the only planet in our solar system that has been habitable. Then generate questions you would like to further investigate to find another Earth-like planet" (TM, page 18). Students then generate a Driving Question Board (DQB).
- 5E1: "Remind students that during the Driving Question Board launch, one category of questions that emerged was related to the Sun (for example, Does the exoplanet have a sun like ours?). Ask students to share more about why they asked these questions. Listen for answers that highlight how the Sun is essential for life because it provides us with heat (not too cold/hot) and light for plants to grow (something about food). Tell students that in order to figure out whether the exoplanet has a sun like ours, we need to make sure we understand what our Sun is like!" (TM, page 33). This last part (which leads into the class activities) is introduced without helping facilitate student curiosity to motivate wanting to understand what our Sun is like.
- 5E1: "Ask students how they think we can investigate further, prompting them to consider what we can observe about the Sun from Earth and how we can observe it. Listen for answers about light and energy and the use of a telescope" (TM, page 35).
- 5E1: "The two questions in this Evaluate phase launch are critical to transitioning from this 5E sequence to the next one. This is how you create a 'need to know' around what's going to happen to our Sun in the future. If students have already brought up these questions, then they can be rephrased or asked differently" (TM, pages 63–64).
- 5E1: "Revisit the Driving Question Board questions and have students identify what they have figured out and what they still need to investigate. Use the Group Learning Routine Domino Discover to hear different pairs' ideas. Prompt students to generate new questions related to finding another star that can potentially support an Earth-like planet…Use questions like the ones above or any other questions related to planet characteristics and whether they have liquid water to transition to the next 5E investigation. Say 'I'm noticing a lot of questions related to planet characteristics and whether they have liquid water, so tomorrow I will have some resources available for the class to investigate these questions.'" (TM, pages 68–69).
- 5E2: "Prompt students to work in pairs to generate questions that can frame the investigation of stars that could support an Earth-like planet. Here is a possible way to frame this prompt: 'We know from Supernova 1054 that stars do not last forever. What do we need to know about the life and death of stars? Keep in mind that we are trying to figure out more about a star that could support an Earth-like planet'…. Have students discuss with a partner which three questions surfaced by the class are most relevant to finding a star that might be able to support an Earth-like planet" (TM, page 82).
- 5E2: "Ask students to think about the data they want to collect as a way to support their engagement in the sensemaking process. If students are having trouble thinking about what

data they want, prompt them to think about the Sun data they examined in the How the Sun Works 5E" (TM, page 84).

- 5E2: "Provide students with the set of star data as cut-out circles. Ask students how they would like to approach investigating relationships among mass, life span, stability, and other star properties. Prompt them to think about how they have looked for relationships between variables in their past math or science classes" (TM, page 93).
- 5E2: "The teacher really needs to act as a facilitator, helping the class navigate from the patterns that came up in the last phase to a need to know about the causal mechanism behind those patterns. It is important to connect the questions for this phase directly to ideas that students raised, or to questions specific students brought up" (TM, page 99).
- 5E2: "Return to student questions from the start of the 5E (the Engage), in order to bring up lingering issues not yet resolved, and new issues that have come up, such as: Why do stars with higher mass fuse hydrogen into helium faster? Can gases burn?" (TM, page 105).
- 5E2: "Ask the following question: How should we investigate why the rate of fusion is faster in massive stars than in less massive stars? Listen for students to say that a model of fusion in stars would be useful for the investigation. If students don't ask for a model on their own, prompt them to think about how they have been able to make observations of processes that are otherwise unobservable during previous parts of this star life cycles investigation" (TM, page 108).
- 5E2: "Revisit the Driving Question Board questions and have students work in pairs to identify what they have figured out and what they still need to investigate, then generate at least one new question related to finding an Earth-like planet….Use questions like the ones above or any other questions related to planet characteristics and whether they have liquid water to transition to the next 5E investigation. Say 'I'm noticing a lot of questions related to planet characteristics and whether they have liquid water, so tomorrow I will have some resources available for the class to investigate these questions'" (TM, pages 118–119).
- 5E3: "If students don't suggest to investigate water in our solar system in order to make claims about water on exoplanets, refer back to the performance task prompt as a way to support them in arriving at the idea that we should study water in our solar system in order to make claims about water in other solar systems" (TM, page 135).
- 5E3: "Students may surface these questions that are relevant to this phenomenon and can be used to transition to analyzing solar system orbital data in the Explore phase…" (TM, page 138).
- 5E3: "Ask students what they think they should look for in the data in order to better understand the water in the solar system phenomenon. Listen for students to say they want to look for evidence of patterns and leverage that to move to step 3" (TM, page 130).
- 5E3: "Explain that the next part of the investigation will address orbital patterns of exoplanets, and ask students for their thoughts on why we are moving from our solar system to looking at planets orbiting other stars" (TM, page 149). This transition is teacher driven.
- 5E3: "Ask students to think about what they have done so far in this 5E investigation and brainstorm ideas for how we can figure out whether the exoplanets stay within the habitable zone throughout an orbit." (TM, page 161).

Student prior experiences are elicited at the beginning of each 5E sequence and are used to connect to, although not often motivate, instructional activities. Related evidence includes:

- 5E1: "Have students turn to a partner and discuss the following prompt about related phenomena: What other phenomena are you familiar with that are associated with a lot of energy? How is that energy being produced?" (TM, page 34).
- 5E1: "Students have background knowledge that can be used to drive the investigation. Listen for the following ideas related to energy and its conservation that students grappled with in middle school: The Sun is a burning ball of gas. There are explosions happening inside the Sun. The Sun is made of chemicals (they may say hydrogen or helium) that are reacting and those reactions produce energy" (TM, page 35).
- 5E2: "Have students turn to a partner and discuss the following prompt about relevant phenomena: What other phenomena are you familiar with that are similar to the Supernova 1054 phenomenon?" (TM, page 80).
- 5E3: "Have students turn to a partner and discuss the following prompt about related phenomena: What other phenomena are you familiar with that are associated with water in different places existing in different phases?... Students have background knowledge that can be used to drive the investigation. Listen for the following ideas related to energy and its conservation that students grappled with in middle school…" (TM, page 137).

Suggestions for Improvement

- Consider including additional guidance throughout each phase of the 5E sequences for teachers to connect students' curiosity and prior understandings to the phenomenon or problem to help students feel like they are driving instruction more consistently.
- For activity introductions and transitions that are currently teacher driven (purple text above), consider including facilitation notes to help teachers elicit student ideas such that students feel like their ideas and curiosity are steering the direction of the activities more frequently.

I.B. THREE DIMENSIONS

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

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

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

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

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

The reviewers found adequate evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions. However, there is often a mismatch between claims of CCC use and evidence of student use of the CCCs. In the overview teacher materials, grade-appropriate elements of the three dimensions are not claimed as learning goals; only categories (e.g., "Patterns") are claimed as learning targets. At the end of individual 5E sequences, though, element-level learning goals are claimed.

Note that the learning goal claims are somewhat confusing for readers, as some lists differentiate between foregrounded and backgrounded learning goals, whereas other lists don't differentiate and the Teacher Materials themselves sometimes focus on learning experiences for SEPs and CCCs that are "backgrounded."

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

The reviewers found extensive evidence that students use the SEPs in this unit because there is a close match between claims and evidence, and students have opportunities to develop new understanding of some of the SEP elements.

Developing and Using Models

- *Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.*
    - Unit Launch: "Provide students with the Anchor Phenomenon: Initial Model handout and have students complete it independently or in pairs. Then have students work in groups of four to collaboratively develop an initial model for why Earth is the only planet in our solar system that has been habitable on poster paper" (TM, page 12).
    - 5E1: This element is claimed. The teacher is told "Using what they learned in the Idea Carousel, have students independently refine their models in their performance task research organizer" (TM, page 65). After students revise their models, the teacher is told, "Have students work in pairs and use their understanding of how our Sun works to

make predictions in relation to the following three questions:" [e.g.,] "What do you predict will happen to the amount of hydrogen over time? What evidence do you have for this?" (TM, page 68).

- 5E2: "Use student responses to decide how to depict the magnitude of the force of gravity vs. fusion force with arrows. In other words, draw arrows with a length that represents the relative magnitude of each force on the molecular cloud image in the Explain handout. Elicit student responses to demonstrate how to explain what is taking place in words. The class should arrive at an explanatory model that connects this early stage in a star's life to massive gravitational pull" (TM, page 101).
- 5E2: This element is claimed. The teacher is told "Allow groups to use peer feedback and ideas shared by other groups to go back and revise their model" (TM, page 114).
- 5E3: "Ask students to independently develop an initial model that explains the phenomenon" (TM, page 137).
- 5E3: This element is claimed. The teacher is told "Tell students that they will now have an opportunity to use evidence of patterns in orbital data to revise their initial solar system models from the Engage phase" (TM, page 145).
- 5E3: "Using what they learned in the Idea Carousel, have students independently refine their models in their performance task research organizer" (TM, page 168).

- *Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.*
  - 5E1: This element is claimed, but there isn't evidence that students use it in this 5E sequence.
  - 5E2: This element is claimed. The teacher is told "Students may not have an understanding that computational models are based on real data. This is highlighted in paragraph one of the text on the first page of the investigation handout. Be sure to unpack this enough so that students know this model is based on evidence. This is particularly important, since they will be using data generated from this model to make evidence-based claims" (TM, page 87). "Students work through the investigation using Star in a Box model to collect data about each group of stars" (TM, page 88).
  - 5E3: "If students have never used Sheets or Excel to create graphs, it may be necessary to take time out for a tutorial at this point. It is important that students create and analyze graphs independently, as this is how they develop the practice of modeling" (TM, page 141).
  - SE3: The teacher is told "Share with students that…the whole point of coming up with these equations is being able to make predictions about other situations, where we don't have as much information" (TM, page 155). Students are then asked to "examine the orbital data below. Then complete the diagram by depicting where the orbits of Planet Zb, Planet Zc, and Planet Zd would lie with respect to Planet Za. Be sure to provide evidence and reasoning from the mathematical model above to support your claims" (5E3 SM, page 10).

Using Mathematical and Computational Thinking

- *Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.*
    - 5E3: This element is claimed.
        - "Deriving a mathematical equation from data will support students in understanding the role mathematical representations play in allowing them to identify patterns that otherwise could not be identified. In this case allowing them to describe the pattern in the relationship between orbital period and average distance more accurately….Explain that a way scientists address this challenge is by representing patterns through equations we can derive from the data. Have students revisit their spreadsheets (using Excel, Google Sheets, or another system) and derive an equation that describes the relationship between the average distance at which a celestial object orbits the Sun and its orbital period" (TM, page 151).
        - Students are asked "How did our mathematical model (Kepler's Third Law) help us describe this pattern more accurately than the graph?" (TM, page 156).
        - "Put students into groups of three to work on calculating the distance between foci in each exoplanet's solar system and construct exoplanet orbits" (TM, page 162).

Constructing Explanations and Designing Solutions

- *Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.*
    - 5E1: This element is claimed, although note that students do not revise their explanations.
        - "After all groups have completed the sequence chart, they are ready to work on putting it together into a scientific explanation" (TM, page 51).
        - The teacher is told "Have students use the ideas surfaced from the data card sort and Class Consensus Discussion to develop an explanation for how the Sun releases energy. Students just constructed an explanation in the previous phase. Encourage students to write their explanations without an organizer, as it is likely that less students will need it at this time. The organizer should only be provided to students who are clearly still struggling to construct their explanations" (TM, page 60).
    - 5E2: This element is claimed.
        - 5E2: "Tell students… 'We have a lot of different ideas circulating in the room right now, and they are in the form of different explanations, based on evidence. It is important for us to get to some agreement on how we represent what we know about different stars' life cycles, so that we have a shared understanding to build upon as we move ahead. To do this, we are going to do

something called a Class Consensus Discussion. First, I will select a few different groups to share their ideas. Then, we will let each group share their claim and discuss what we can agree to as a class.' You may decide to walk students through the entire poster or take them through the steps as you facilitate it" (TM, page 103).

- Although this SEP category is claimed as a focus of learning, the performance task at the end of each 5E sequence is designed to support students to create and revise arguments rather than explanations. In addition, the second part of the element is not explicitly discussed in the unit.

Engaging in Argument from Evidence

- An element from this SEP category is not claimed in the unit. A note to the teacher in the "Arguing from Evidence" rubric says **"**The argument students are asked to develop in this unit is at the NGSS middle school level. We encourage teachers to use the performance task argument in this unit as a formative assessment of whether students are proficient in argument at the middle school level. This will provide data that can be used to inform support for arguing from evidence at the NGSS high school level during subsequent units in this course" (TM, page 29).
- Unit Launch: "Prompt students to provide a written argument from evidence about which exoplanet in the performance task is most likely to be habitable…Remind students that it is important that they not only cite evidence from the exoplanet data set, but that they also connect that evidence to their claim by using ideas from their final models and other ideas from the unit" (TM, page 21).
- Student arguments are revised at the end of each 5E sequence as part of the repeated performance task (e.g., TM, page 21).

Obtaining, Evaluating, and Communicating Information

- *Communicate scientific ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).*
    - This element is part of a claimed PE target in the unit. Students have many opportunities in the unit to communicate their ideas about phenomena and possible design solutions related to finding a habitable planet. Students share their ideas orally, in writing, and through models. For example:
        - 5E2: As students discuss their data, the teacher is given "suggested conferring questions" for students to answer orally, including: "Are there any patterns in the graph? What is your evidence?" (TM, page 95).
        - 5E3: The teacher is told "after students work independently on one star, have groups of three use the group learning routine Think-Talk-Open Exchange to share what they figured out: how they constructed the orbit for their assigned exoplanet; how each variable in Kepler's First Law of Planetary Motion is represented in their model; and their conclusions about whether the planet stays within the habitable zone throughout its orbit" (TM, page 162).

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

The reviewers found extensive evidence that students use or develop the DCIs in this unit. There are sufficient DCI elements developed in the unit and there is a match between the DCI elements claimed and those that are developed and used in the unit. Additionally, students use the DCIs in service of making sense of the unit phenomena or solving a problem.

ESS1.A: The Universe and Its Stars

- *The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.*
    - 5E1: This element is claimed. The teacher is told to "tell students that they are now going to use the evidence and ideas they have gathered to make a claim about the Sun's composition and continue working toward an agreement about how the Sun works. Provide students with a set of cards that correspond to the sunlight investigation they carried out. Tell them that their task is to look at the information and images on each card and decide how to sequence them in a way that would allow someone else to understand how you can determine the composition of the Sun. As students work, support them in making sense of the information in the cards and putting things in order" (TM, page 47).
    - 5E 2: This element is claimed. Students use star spectra data to make claims about the composition of other stars and make claims about the causes of differences in brightness (e.g., the "the different in brightness has to do with distance") (e.g., TM, page 85).
- *Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.*
    - 5E2: This element is claimed. The teacher is told to "Introduce the game called Iron [26] that will allow students to model nuclear fusion in stars. Provide students with the Elaborate handout and organize them into groups of two. Have students complete the first page of the Elaborate handout, where they will read the intro text, play with the Iron [26] game, and brainstorm ideas for how they can use the game to model nuclear fusion in a high and low mass star. Facilitate a discussion to agree how the class should model fusion in a lower mass star vs. a high mass star" (TM, page 108).
- *The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.*
    - 5E1: This element is claimed. Students focus on figuring out "how the sun works" including its relative stability for the last five billion years (e.g., TG, page 64).
    - 5E2: This element is claimed. The teacher is told to "have students revisit the life on Earth time scale from the Anchor Phenomenon and respond to the following questions independently: What do we need to know about other stars to determine if they are as stable as our Sun? What are the factors that contribute to a planet's stability for supporting life? Ask students to consider their responses to these questions and what

they have figured out about star life cycles, then represent their ideas about why the Sun has been able to support a planet where life has been able to exist and evolve on their initial group models from the performance task launch" (TM, page 113).

ESS1.B: Earth and the Solar System

- *Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.*
  - 5E3: This element is claimed. The teacher is told to "orient the class to the purpose and the format of a class consensus discussion. You may say something like this: 'We are going to use a Class Consensus Discussion, just like we did a few days ago, to learn about all the thinking in the room and come to some decisions about what our mathematical model has helped us figure out about the orbit, and the potential for water, on exoplanets in our data set.' The share will be about responses to the following prompts from the *Explain 2: Applying our mathematical model of orbits to exoplanets* handout: The graph of orbital period vs (sic) semi major axis length allowed us to identify a pattern in the relationship between these two variables. How did our mathematical model (Kepler's Third Law) help us describe this pattern more accurately than the graph? Based on your calculations, which exoplanets travel within the habitable zone when they are at the average distance from their star? Be sure to cite evidence. Does this mean that they orbit within the habitable zone throughout their orbital period of revolution around their star? What other information would you like to have?" (TM, page 157).

PS3.D: Energy in Chemical Processes and Everyday Life

- *Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation.*
  - 5E1: This element is claimed. The teacher is told to "present students with the task of analyzing data in the table Possible Energy-Releasing Processes in the Sun. They can use information in the table as evidence either to support their original claims or change their claims" (TM, page 56).
  - 5E2: This element is claimed. Students model nuclear fusion in stars (e.g., TM, page 109) and sample student models show energy reaching Earth as radiation.

PS4.B: Electromagnetic Radiation

- *Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities.*
  - 5E1: This element is claimed. The teacher is told to "provide each student with the Investigating Light from the Sun handout. Each group should have a laptop to navigate to the Three Views Spectrum Demonstrator. Launch students into working on questions 1-4 as they work with the simulator. Support students in using the simulation, keeping in mind that it is important for them to make sense of what they are observing

independently" (TM, page 39). Students engage with the Spectrum Demonstrator and are asked guiding questions such as "Does the spectra of the white light look the same when it passes through the hydrogen gas?" Students then compare different spectra to determine that the same type of gas always produces the same spectral pattern (e.g., TM page 41).

- 5E2: This element is claimed. Students use their understanding from the first 5E sequence to analyze data from spectra of other stars. For example, an anticipated student idea is "The sample spectra of stars indicates they are made of hydrogen and helium just like our Sun" (TM page 85).

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

The reviewers found adequate evidence that students have the opportunity to use or develop the CCCs in this unit. Students are supported to develop some CCCs and have many opportunities to use grade-appropriate CCC elements in service of making sense of phenomena. However, there is often a mismatch between claims of CCC use and evidence of student use of the CCCs.

Patterns

- *Empirical evidence is needed to identify patterns*.
  - Unit Launch: Example student work for the initial performance task is shown, claiming to use the CCC of **Patterns** "where appropriate" (TM, page 24). However, there isn't evidence that the student work includes Grades 9–12 level CCC element use. Note that Grades 9–12 CCC element use isn't required here in the beginning of Unit 1, but without specifying the level, readers could assume that the high school unit elicits Grades 9–12 elements.
  - 5E1: This element is claimed. In this 5E sequence:
    - Students are prompted to answer the question: "What pattern do you notice in the sunlight data across the 3 observations? Describe the evidence for the pattern" (TM, page 40). The teacher is told "If students do not cite the numbers (wavelengths) under the black lines are the same in each spectra as empirical evidence of the pattern, ask them to cite evidence that the black lines are in the same place, as needing empirical evidence to identify patterns is an important element of CCC #1 – Patterns" (TM, page 40). Note, however, that the sample student response shown does not include evidence of student use of this understanding, as students only mention evidence for the pattern rather than note that empirical evidence is required to identify a pattern.
    - As students develop their explanations, the teacher is told "Students will be using patterns as evidence for their claim, which is a middle school element of CCC#1 - Patterns. Needing empirical evidence to identify a pattern is an important high school element of CCC#1 - Patterns. The conferring question about patterns is designed to support students in developing this high school element of patterns" (TM, page 51).

        - During a class discussion, a suggested teacher prompt is: “How can you ensure that others are convinced that the patterns you are citing are truly patterns?” (TM, page 53). If this suggested prompt is used, it would help to develop this element.
        - On the Summary task, one of the student prompts is: “If someone claimed that there are no patterns in the spectra of the Sun and in the spectra of each of the gases, what could you say to convince them there are patterns?” (5E1 SM, page 10).
    - 5E3: This element is claimed.
        - Students are asked: “What patterns did you see in the orbital data? How did graphing the orbital data help you to identify evidence of these patterns?” The teacher is told “At this point they [the students] should name the specific empirical evidence they used to identify different patterns. If they do not, prompt them to do so” (TM, page 147). However, even if students name specific empirical evidence, that response is weak evidence that they understand that empirical evidence is needed to identify patterns.
        - Students are asked “What patterns do you see in the simulation? What is your evidence?” The teacher is told that “Students should, at this point, be used to seeking out patterns as a way to make sense of simulations and data sets!” (TM, page 150). However, there isn’t evidence that students will consider whether any evidence from the simulation is empirical evidence, although students may assume anything from NASA reflects the real world.
- *Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.*
    - 5E2: This element is claimed. A teacher note says “The prompt about patterns in the Class Consensus Discussion is in support of students’ use of CCC #1 - Patterns, specifically the idea that different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. So far stars have been investigated at the scale of our solar system (How the Sun Works) and of a super cluster (Star in a Box). Patterns identified at both scales were necessary to make sense of why stars change” (TM, page 104). However, the student prompts referred to (e.g., “How does the rate of star death relate to luminosity of a star [amount of energy released per second?]”) don’t provide evidence that students use the claimed CCC element, although they build toward it. A sample “key point” that may come from discussion shows more evidence for this element: “If we would have only studied the sun, we only would have observed the pattern in the Sun’s spectra that led to our understanding of the role of nuclear fusion, but we would not have seen the patterns of how stars change and the relationship with mass” (TM, pages 104–105). Later, the teacher is told “Assess student understanding of CCC #1 Patterns independently by asking each student to respond to the following prompt: Why was it important to study stars at the scale of the supercluster (Star in a Box and Mapping Stars), of one star (How the Sun Works), and at the atomic level (Fe-26) in order to

explain the phenomenon of star stability and change? Would we have been able to explain how and why stars change and why the most massive stars change fastest without studying stars at all three scales?" (TM, page 111).

- *Mathematical representations are needed to identify some patterns.*
    - 5E3: This element is claimed.
        - Students are asked "What patterns did you see in the orbital data? How did graphing the orbital data help you to identify evidence of these patterns?" (TM, page 147).
        - "Deriving a mathematical equation from data will support students in understanding the role mathematical representations play in allowing them to identify patterns that otherwise could not be identified. In this case allowing them to describe the pattern in the relationship between orbital period and average distance more accurately" (TM, page 151).

Scale, Proportion, and Quantity

- *The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.*
    - Unit Launch: Example student work for the initial performance task is shown, claiming to use the CCC of **Scale, Proportion, and Quantity** "where appropriate" (TM, page 24). However, there isn't evidence that the student work includes high school-level CCC element use. Note that high school CCC element use isn't required here in the beginning of Unit 1, but without specifying the level, readers could assume that the high school unit elicits high school elements.
    - 5E1: This element is claimed. The teacher is told that students are beginning to develop it: "In this case, students should be able to use the idea of scale as scientific reasoning that links the evidence of how much energy is produced by the Sun, energy produced by chemical reactions, and energy produced by nuclear fusion to the claim that nuclear fusion occurs in the Sun. Energy produced by chemical reactions would not account for the quantity of energy the Sun has produced per second for 5 billion years, whereas energy from nuclear fusion does" (TM, pages 56–57).
- *Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).*
    - 5E3: This element is claimed. Students are asked "How did our mathematical model (Kepler's Third Law) help us describe this pattern more accurately than the graph?" (TM, page 156). Later, the teacher is told "after students work independently on one star, have groups of three use the group learning routine Think-Talk-Open Exchange to share what they figured out: how they constructed the orbit for their assigned exoplanet; how each variable in Kepler's First Law of Planetary Motion is represented in their model; and their conclusions about whether the planet stays within the habitable zone throughout its orbit" (TM, page 162).

Energy and Matter

- *In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.*
  - 5E2: This element is claimed. Students model nuclear fusion in stars and therefore use or implicitly develop this element, but this idea is not explicitly discussed.

Stability and Change

- General. In the following activities, a claim to this CCC category seems to be made, but there is no clear link to a high school-level CCC element:
  - Unit Launch: Students' performance task asks them to respond to the prompt: "How does the concept of stability and change help support your argument?" (TM, page 21).
  - Unit Launch: Example student work for the initial performance task is shown, claiming to use the CCC of **Stability and Change** "where appropriate" (TM, page 24). However, there isn't evidence that the student work includes high school-level CCC element use. Note that use of a high school CCC element isn't required here, but without specifying the level, readers could assume that the high school unit elicits high school elements.
  - 5E3: "The following prompts may help with surfacing key ideas through the lens of Stability and Change: ● What patterns did you see in the orbital data? How did graphing the orbital data help you to identify evidence of these patterns? ● In what ways is each planet's orbit allowing for the stable existence of water? ● What factors are causing the phase of water to change or stay the same?" (TM, page 147).
- *Much of science deals with constructing explanations of how things change and how they remain stable.*
  - 5E2: This element is claimed. In the summary handout, students are asked to respond to the question: "Why might figuring out why things change and why they stay the same be something important to think about when investigating phenomena or finding solutions to problems?" (5E2 SM, page 23).

Suggestions for Improvement

General

- For all three dimensions, consider clarifying claims to match what students do in the unit. For example, if an element is only partially developed or used in a 5E sequence (e.g., only the first part of a two-clause element is used), the partial use could be explicitly mentioned to teachers to avoid confusion.
- Consider discussing parts of the three dimensions using specific element-level language rather than category names. For example, instead of mentioning to the teacher to support the idea of "stability and change" in the unit launch, specific ideas could be described. This would help to clarify whether students are meant to be applying prior learning or developing new high school-level learning.

Science and Engineering Practices

N/A

Disciplinary Core Ideas
N/A

Crosscutting Concepts
Consider additional opportunities for students to explicitly think about their use of specific elements of the CCCs — in particular, for the Energy and Matter targeted element — and how these concepts are useful in multiple contexts.

I.C. INTEGRATING THE THREE DIMENSIONS

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

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

The reviewers found extensive evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena and designing solutions to problems. Students have many opportunities to integrate three dimensions in service of sense-making and problem solving, and one-dimensional learning is rare in the unit.

Three-dimensional learning performances are claimed for each lesson, and the following performances are examples of those that show evidence of student use (see Criterion I.B):

- 5E1: "Students revise and critique their models (SEP: **Developing & Using Models**) for why Earth has been such an ideal place for life to exist and evolve using empirical evidence of patterns in the Sun's spectra (DCI: **ESS1.A The Universe and Its Stars**) and lab samples of elemental gases and comparisons of scale (duration and quantity) (CCC: **Scale, Proportion and Quantity**) of energy released by the Sun (DCI: **ESS1.A The Universe and Its Stars**)" (TM, page 32).
- 5E2: "Students develop and analyze a mathematical model (SEP: **Developing & Using Models**) in order to be able to identify evidence of patterns (CCC: **Patterns**) in the relationships between observable star properties and lifespan (DCI: **ESS1.A The Universe and Its Stars**)" (TM, page 78).
- 5E2: "Students collect data from a computational model (SEP: **Constructing Explanations and Designing Solutions**) of nucleosynthesis in stars (DCI: **PS3.D Energy in Chemical Processes and Everyday life**) in order to identify patterns (CCC: **Patterns**) in the relationship between mass of a star (DCI: **ESS1.A The Universe and Its Stars**) and nucleosynthesis (DCI: **PS3.D Energy in Chemical Processes and Everyday life**)" (TM, page 78).
- 5E3: "Students critique and revise their models (SEP: **Developing and Using Models**) for why Earth has been an ideal planet for sustaining life, using evidence generated by a mathematical

model (SEP: **Using Mathematical and Computational Thinking**) and algebraic thinking (CCC: **Scale, Proportion and Quantity**) to represent the idea that stable temperatures and the maintenance of liquid water on Earth result from features of the motions of orbiting objects (DCI: **ESS1.B: Earth and the Solar System**)" (TM, page 134).

Suggestions for Improvement

Increasing the match between CCC claims and evidence of student use would increase opportunities for students to perform three-dimensionally at the high school level.

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 *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that lessons fit together coherently to target a set of performance expectations (PEs) because the lesson themes and content are sequenced coherently from the students' perspectives. Lessons build directly on prior lessons and materials make the links between lessons clear to the students. Students have regular opportunities to engage in asking questions based on what they have learned so far in the unit and revisit their questions in subsequent lessons. Unit materials also support students in developing proficiency in the targeted performance expectations.

Most lessons build directly on prior lessons and make the links between lessons mostly clear to the students. As students move through the unit, part of what they figure out is used as the next question(s) to pursue. Students also have opportunities to engage in asking questions based on what they have learned so far in the unit and revisit their questions in subsequent lessons. Evidence includes:

- Unit Launch: This learning sequence ends with students generating questions students would like to further investigate to find another Earth-like planet. The next lesson (How the Sun Works, Engage) begins with students reviewing questions from the previous lesson. However, the information gathered in the Engage lesson is not revisited at all during the next lesson (Explore); it is revisited in the Explain lesson.

- 5E1: "Remind students that during the Driving Question Board launch, one category of questions that emerged was related to the Sun (for example, Does the exoplanet have a sun like ours?). Ask students to share more about why they asked these questions. Listen for answers that highlight how the Sun is essential for life because it provides us with heat (not too cold/hot) and light for plants to grow (something about food) (TM, page 33). Students discuss their prior knowledge of the Sun, and the teacher is told to "end the discussion by telling them that they will next be conducting an investigation of sunlight to see if they can figure out what the Sun is made of and how it works" (TM, page 36).
- 5E1: Each step of the 5E is connected to prior steps. For example, at the beginning of the Elaborate step, the teacher is told to "Remind students that while they have determined that the Sun is composed of hydrogen and helium, they still do not know how those components release energy" (TM, page 56).
- 5E1: "The two questions in this Evaluate phase launch are critical to transitioning from this 5E sequence to the next one. This is how you create a 'need to know' around what's going to happen to our Sun in the future. If students have already brought up these questions, then they can be rephrased or asked differently" (TM, pages 63–64).
- 5E1: "Use questions like the ones above or any other questions related to planet characteristics and whether they have liquid water to transition to the next 5E investigation. Say 'I'm noticing a lot of questions related to planet characteristics and whether they have liquid water, so tomorrow I will have some resources available for the class to investigate these questions'" (TM, page 69).
- 5E2: "Remind students that, during the Evaluate phase of the previous 5E, they concluded that one of the reasons Earth has been able to sustain life is that our Sun has provided Earth with the right amount of energy for liquid water to exist for over 4 billion years. After the previous 5E instructional sequence on How the Sun Works, a category of questions that emerged was about the future of other stars" (TM, page 79).
- 5E2: "Provide some framing for the class about where we are in the investigation of stars: 'During the Explore 2 phase, your class surfaced many patterns in the way different stars change over time. We began to discuss the implications these patterns have for your search for a star that can support a planet that might sustain life. But we figured out that we still have some questions about how and why we see these changes….Now let's figure out how forces within stars cause different groups of stars to change over time'" (TM, page 99).
- 5E2: "While students are responding, listen for these ideas, to provide a bridge to the text:…. Leverage student responses to transition into the text on page 1 of the Explain: How and Why do Stars Change? Handout" (TM, page 100).
- 5E2: "Remind students that at the end of the Explain phase it was established that the class has made a claim (massive stars die and change faster than less massive stars because the rate of fusion is faster) based on evidence (rate of hydrogen fusion into helium data in stars of different masses), but they still do not have scientific reasoning to complete their explanations" (TM, page 108).
- 5E3: The 5E sequence begins with "Remind students that, during the Driving Question Board launch, one category of questions that emerged was related to the temperature and the

existence of liquid water on the exoplanets (for example, Does the planet have the right temperature to sustain life? Does the Planet have liquid water?)" (TM, page 135).

- 5E3: "Remind students that, at the end of the Engage phase, they surfaced the idea that they need to investigate the distance Comet Borrelly is from our Sun and the characteristics of Comet Borrelly's orbit. 2) Tell them that they will be looking for evidence of patterns in orbital data from our solar system in order to make sense of the phase changes of water on Comet Borrelly" (TM, page 140).
- 5E3: "Explain that the next part of the investigation will address orbital patterns of exoplanets, and ask students for their thoughts on why we are moving from our solar system to looking at planets orbiting other stars" (TM, page 149). Although this transition is teacher driven, students are supported to understand the transition.

"This unit is designed so that, by the end of this unit, students can meet PEs from NGSS/NYSSLS. Three PEs were bundled for Unit 1" (TG, page 5). The following PEs are claimed, and the individual elements from each are developed in the unit (see evidence in Criterion I.B):

- **HS-ESS1-1** Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.
- **HS-ESS1-3** Communicate scientific ideas about the way stars, over their life cycle, produce elements.
- **HS-ESS1-4** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

Suggestions for Improvement

N/A

I.E. MULTIPLE SCIENCE DOMAINS

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

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

ii. The usefulness of crosscutting concepts to make sense of phenomena or design solutions to problems across science domains is highlighted.

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

The reviewers found extensive evidence that links are made across the science domains when appropriate. Most of the unit focuses on ideas from the physical and Earth and space sciences to make sense of the idea that Earth is habitable and what factors might predict other habitable planets. The unit materials focus on one Earth and space sciences DCI and three physical science DCIs. All claimed DCIs support one another and are explicitly linked for students as they focus on the criteria for what makes Earth able to sustain life.

There are also some links to life sciences when discussing what people need to survive, but these are not needed at the high school level to make sense of the phenomena or solve the problems. For example, in 5E1: "Listen for answers that highlight how the Sun is essential for life because it provides us with heat (not too cold/hot) and light for plants to grow (something about food)" (TM, page 33).

Crosscutting concept use is made explicit for students as a general tool that can be helpful for sense-making and problem solving. In 5E2 in the summary handout, students are asked to respond to the question: "Why might figuring out why things change and why they stay the same be something important to think about when investigating phenomena or finding solutions to problems?" (5E2 SM, page 23). In this example, students are asked to think about the utility of this CCC element broadly, across science domains.

Suggestions for Improvement

Consider providing additional guidance on ways students could connect the CCCs across science domains so students can see the importance of the CCCs as tools that can be used to make sense of concepts in all science domains. For example, in SE3 Explain 2, students are supported to realize how helpful the following concept is for their current sense-making: *Mathematical representations are needed to identify some patterns.* The explicit discussions about this element could be extended slightly to ensure students realize this is useful in more cases than only when calculating astronomical phenomena.

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 *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials provide grade-appropriate connections to the Common Core State Standards (CCSS) in mathematics and English language arts (ELA). CCSS connections in mathematics and ELA/Literacy are listed at the beginning of the Teacher Materials (TM, pages 8–9). These connections are not called out during the lesson activities, but a table at the end of each of the three 5E sequences lists which 5E phase (Engage, Explore, etc.) uses which CCSS (e.g., TM, page 72). Throughout the unit, students use writing and reading skills to explain and communicate their understanding of scientific concepts and students use mathematics skills to explain the results of investigations. In addition, the utility of literacy and mathematics skills for scientific sense-making is made explicit for students, and students have extensive opportunities for pair and small group discussions. However, student reading material is limited to short educative texts and tables. Primary source documents are not used as reading materials.

Related evidence includes:

- 5E1: "CCSS.ELA.Literacy. WHST.9-10.9: Draw evidence from informational texts to support analysis, reflection, and research. Students complete the sequence chart and now they are ready to work on putting it together into a scientific explanation. Ask students to construct explanations about the Sun's composition. Select two or three groups' scientific explanations to share with the class. The point of this discussion is to elevate ideas that move the class towards greater understanding of how the Sun releases energy" (TM, page 52).
- 5E2: "CCSS.ELA.Literacy. WHST.9-10.9: Draw evidence from informational texts to support analysis, reflection, and research. Display or provide a handout of the hydrogen/helium ratio data of one solar mass stars. This is the data students analyzed and interpreted in the Elaborate phase of the How the Sun Works 5E. Highlight the fact that the data showed the Sun would run out of hydrogen fuel after a life span of 10 billion years. Ask students what they think we should consider about stars if we want to determine how long their life spans are and to record their answer" (TM, page 87).
- 5E2: "Tell them [students] that reading this text will provide them with some additional details about the forces that govern changes within a star, which they will use to develop their explanatory models for changes that take place during a star's life cycle" (TM, page 100). In this example, the usefulness of their reading for their science learning is pointed out to students.

- 5E3: "HSA-SSE.A.1: Interpret expressions that represent a quantity in terms of its context. Have students work in pairs to complete the Explain 2: Applying our mathematical model of orbits to exoplanet orbits handout. As students are working, consider which groups should share in the class consensus discussion to surface many viewpoints" (TM, page 156).
- 5E3: "HSA-CED.A.2: Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. 'We are going to use a Class Consensus Discussion, just like we did a few days ago, to learn about all the thinking in the room and come to some decisions about what our mathematical model has helped us figure out about the orbit, and the potential for water, on exoplanets in our data set.' The share will be about responses to the following prompts from the Explain 2: Applying our mathematical model of orbits to exoplanets handout: The graph of orbital period vs (sic) semi major axis length allowed us to identify a pattern in the relationship between these two variables" (TM, page 156). In this example, the usefulness of mathematics to science sense-making is pointed out to students.
- Students engage in pair, small group, and class discussions throughout the unit, and are sometimes facilitated to engage in oral feedback routines that provide additional practice speaking and listening. For example:
    - 5E2: "Mix up the student pairs, so that students are in triads with people they have not worked with on the Fe-26 game. Have the groups complete a Think-Talk-Open Exchange to help students articulate their ideas in response to questions. Here students will share with others and gain feedback on their ideas by finding similarities and differences" (TM, page 110).
    - 5E2: "After students work independently on one star, have groups of three use the group learning routine Think-Talk-Open Exchange to share what they figured out. Here students will share with others and gain feedback on their ideas by finding similarities and differences. Use the table below for guidance on the answers to expect from students" (TM, page 163). Note that the Key Points Table contains facts to be used for clarification purposes, not supports for teachers to provide students with feedback.

Suggestions for Improvement

Consider supporting additional variety in writing assignments.

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

CATEGORY II

NGSS INSTRUCTIONAL SUPPORTS

II.A. RELEVANCE AND AUTHENTICITY

II.B. STUDENT IDEAS

II.C. BUILDING PROGRESSIONS

II.D. SCIENTIFIC ACCURACY

II.E. DIFFERENTIATED INSTRUCTION

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

II.A. RELEVANCE AND AUTHENTICITY

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

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

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

iii. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience.

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

The reviewers found adequate evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world because each 5E sequence provides at least one opportunity to make connections between the phenomena and students' lives. The phenomena and classroom activities used are engaging to students, reflect grade-appropriate scenarios, and encourage curiosity from students. However, not all phenomena are presented as directly as possible, and explicit support for teachers to cultivate questions from students that come from their background and culture is not present in the materials.

The phenomena are relevant to students, and students experience the phenomena and problems, as directly as possible in many cases. For example:

- Unit Launch: The overall driving problem for the unit is that Earth may become less habitable. Students are encouraged to think of solutions, including finding another planet. This problem of Earth's habitability may be motivating and relevant to students, although it is focused on a global scale and not connected to the climate effects in students' communities. Therefore, students may feel that this is a futuristic, science fiction problem.
- Unit Launch: Students are introduced to the unit's anchoring phenomenon (Earth as an ideal place to support life) by watching a video about the diversity and evolution of life on our planet.
- 5E1: Students do not experience the investigative phenomenon as directly as possible (e.g., through data): "Have students read the investigative phenomenon for this 5E sequence, found at the top of the Engage phase handout" (TM, page 34). Later, though, students experience related phenomena more directly: "Provide each student with the Explore 1: Investigating Light from the Sun handout. Each group should have a laptop to navigate to the Three Views Spectrum Demonstrator. Launch students into working on questions 1–4 as they work with the simulator. Support students in using the simulation, keeping in mind that it is important for them to make sense of what they are observing independently. Some Students may have very

little to no experience with a spectrometer. If they are available have students observe light through them and have several students share out about what they observe. This real-life experience will help support students in making sense of the spectrum demonstrator. Since the simulator has the word 'spectrum' in its name, students may be prompted to remember what a spectrum is. If not, it is fine to remind them of the concept of spectra and rainbows, which is something they are likely to have covered at least once since elementary school" (TM, page 38).

- 5E2: Students experience the investigative phenomenon (star explosion) through video, text, and image (TM, page 80). For example: "Transition into the investigation on the next Explore 1 handout, What Kinds of Stars Have Long and Stable Life Spans?, where they will be using a computational model that allows them to observe predicted life spans and changes in stars of different masses (or amount of hydrogen)" (TM, page 83).
- 5E3: Students experience the investigative phenomenon (comet) through a video and data (TM, page 136).

Students have some opportunities to connect instruction to their lives and communities. For example:

- At the beginning of each 5E sequence, students are asked whether they have seen related phenomena. For example, in 5E1: "Ask students to independently brainstorm ideas in response to the following prompts: What are your ideas for how the Sun provides so much energy? What did you observe in the video or in your life that made you think this?......Asking students to think about a similar phenomenon they are familiar with will help them connect to ideas about energy they already know. This will help all students generate initial ideas about how the Sun works and make it more relevant to their own lives" (TM, page 34).
- "During the Evaluate phase of each 5E, students evaluate their work on the performance task against a rubric, that also prompts them to reflect upon how what they have learned has relevance to their lives. We recommend that teachers facilitate a whole class share or discussion around the relevance of learning during this 5E to students' lives; responses can then be displayed somewhere in the classroom" (TG, page 22). For example, in 5E1: "All students have observed and felt the Sun throughout their lives. The prompts at the end of the rubric are designed to support students in pausing to reflect about why their new ideas are relevant to their lives. After students complete the reflection prompts independently, consider facilitating a whole class share about why learning during this 5E is relevant to students' lives and displaying their responses somewhere in the classroom. This can foster relevance and belonging for all students" (TM, page 65). Prompts include: "What is one idea and/or skill you learned that you think is important to teach someone in your family or community?" (5E1 SM, page 15).
- 5E Instructional Cycle 2, Star Life Cycles, Explore 1: "Prompt students to answer the questions on the Explore 1 handout individually, then discuss with a partner. The purpose of this prompt is to get students to notice that, from Earth, we mostly see stars as little white dots of light. This is different from the view from a space telescope (like Hubble) which they will see in a moment. Ask some of the pairs to share out their observations and thoughts about what they might see if they viewed the same stars through an even more powerful telescope that's in space" (TM, Page 84).

- 5E3: "Have students turn to a partner and discuss the following prompt about related phenomena: What other phenomena are you familiar with that are associated with water in different places existing in different phases?" (TM, page 137).
- The teacher is not supported to elicit student questions that connect to their backgrounds or communities.

Suggestions for Improvement

- Most of the connections to students' lives are made at the end of each 5E sequence rather than at the beginning to help make the learning relevant. Consider connecting the unit anchor phenomenon launch and driving problem more directly to students' communities.
- Consider including explicit teacher guidance on how to cultivate questions from students that come from their everyday lives or culture.
- Consider providing a real-world context before students participate in the Engage Lesson of Instructional Cycle 2 Star Life Cycles.
- Consider connecting the Anchor Phenomenon Launch problem more often throughout the unit. Focusing on how students can connect what they see in their everyday lives and how that contributes to the negative changes on Earth could help students make more meaningful, authentic connections to their learning.

II.B. STUDENT IDEAS

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

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

The reviewers found extensive evidence that the materials provide students with opportunities to both share their ideas and thinking and respond to feedback on their ideas. Students have frequent opportunities to share ideas with peers and to use peers' ideas to change or improve their own thinking. However, explicit evidence of the teacher providing feedback could not be located.

Students are supported to express, clarify, and justify their ideas. Related evidence includes:

- Unit Launch: Students are asked to work in groups to share their ideas about the anchor phenomenon. Discussion prompts are given to the teacher to help students share and justify their thinking, including "Why do you think this detail is important?" and "How did you agree, as a group, to the overall story?" (TM, pages 14–15).

- Unit Launch: "Have students independently brainstorm possible solutions that will ensure the survival of the human species" (TM, page 15).
- 5E1: "What are your ideas for how the Sun provides so much energy? What did you observe in the video or in your life that made you think this?" (TM, page 34).
- 5E1: Suggested teacher prompts include: "I see you cited a pattern as evidence, how do you know there is a pattern? How can you make that clear in your explanation?" (TM, page 51).
- 5E1: "Say: We have a lot of different ideas circulating in the room right now, and they are in the form of different evidence-based claims. It is important for us to get to some agreement on how we represent what we know about how the Sun works, so that we have a shared understanding to build upon as we move ahead. To do this, we are going to do something called a Class Consensus Discussion. First, I will select a few different groups to share their ideas. Then, we will let each group share their claim and discuss what we can agree to as a class" (TM, page 52).
- 5E2: As students discuss their data, the teacher is given "suggested conferring questions," including: "Are there any patterns in the graph? What is your evidence?" (TM, page 95).
- 5E2: "Have students independently read the text using the following text annotation strategy and then share their annotations with a partner to discuss their learning" (TM, page 100).

Students have multiple opportunities to receive written and oral peer feedback, but guidance related to teacher feedback was not found. Related evidence includes:

- 5E1: "Facilitate student critique of one anothers' models through the Group Learning Routine Idea Carousel. Have students annotate other groups' models using post-its. Each post it (sic) should have a symbol and comment from each of the following categories: c. Write a check on post its (sic) with comments about ideas represented in the model that resonate. d. Write a plus symbol on post its (sic) with comments about ideas that should be added to the model. e. Write a question mark on post its (sic) with comments about ideas that you don't think are relevant to the model. f. Write a delta symbol on post its (sic) with comments about suggestions for how to clarify an idea or represent it more clearly….Allow groups to use peer feedback and ideas shared by other groups to go back and revise their model." (TM, page 64).
- 5E1: "Assign students to partnerships and have them review one another's work and self-assessment and provide feedback on the accuracy of the self-assessment. 4) Give each student an opportunity to revise their model using what surfaced from their self-assessment and/or feedback" (TM, page 65).
- 5E2: "Mix up the student pairs, so that students are in triads with people they have not worked with on the Fe-26 game. Have the groups complete a Think-Talk-Open Exchange to help students articulate their ideas in response to questions. Here students will share with others and gain feedback on their ideas by finding similarities and differences" (TM, page 110).
- 5E2: "Facilitate student critique of one anothers' models through the Group Learning Routine Idea Carousel. Have students annotate other groups' models using post-its. Each post it (sic) should have a symbol and comment from each of the following categories: Write a check on post its (sic) with comments about ideas represented in the model that resonate. Write a plus symbol on post-its with comments about ideas that should be added to the model. Write a question mark on post-its with comments about ideas that you don't think are relevant to the

model. Write a delta symbol on post-its with comments about suggestions for how to clarify an idea or represent it more clearly…Allow groups to use peer feedback and ideas shared by other groups to go back and revise their model" (TM, page 114).

- 5E2: "After students work independently on one star, have groups of three use the group learning routine Think-Talk-Open Exchange to share what they figured out. Here students will share with others and gain feedback on their ideas by finding similarities and differences. Use the table below for guidance on the answers to expect from students" (TM, page 163). Note that the Key Points Table contains facts to be used for clarification purposes, not supports for teachers to provide students with feedback.
- 5E3: "Facilitate student critique of one anothers' models through the Group Learning Routine Idea Carousel. Have students annotate other groups' models using post-its. Each post it (sic) should have a symbol and comment from each of the following categories: a. Write a check on sticky notes with comments about ideas represented in the model that resonate. b. Write a plus symbol on sticky notes with comments about ideas that should be added to the model. c. Write a question mark on sticky notes with comments about ideas that you don't think are relevant to the model. d. **Δ** Write a delta symbol on sticky notes with comments about suggestions for how to clarify an idea or represent it more clearly… Allow groups to use peer feedback and ideas shared by other groups to go back and revise their model" (TM, page 167).

Suggestions for Improvement

- Consider adding prompts for the teacher to provide students with feedback on their ideas.
- Consider providing students a checklist, sentence stems, or a rubric that they can use when providing peer feedback, in addition to the rubric used for feedback on the self-assessments.

II.C. BUILDING PROGRESSIONS

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

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

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

The reviewers found extensive evidence that the materials identify and build on students' prior learning in all three dimensions. Guidance is provided about students' expected prior learning from middle school, and some progressions information is described related to what students will learn in the unit. However, descriptions of exactly how and where this learning progresses for students were not found.

Related evidence includes:

- Information is given about placement of the unit instruction within students' high school experiences: "This unit was intentionally designed to begin a year-long course" (TG, page 1). "This unit should be completed during the first month or two of school" (TG, page 8).
- The unit is connected to prior learning from middle school:
    - Teacher Guide: "It is helpful to consider the middle school standards in order to enact a unit that builds on students' prior experiences. As we are in the middle of a multi-year transition, however, it is also critical to keep in mind that not all students will have experienced an NGSS-designed unit when they come to high school, so the process of building on middle school learning may be particularly complex for years to come" (TG, page 7). Middle school-level elements from all three dimensions that are needed as prior learning are also listed.
    - 5E1: "Students have background knowledge that can be used to drive the investigation. Listen for the following ideas related to energy and its conservation that students grappled with in middle school…The energy is potential energy stored in atoms and molecules the Sun is made of. (MS.PS1.B, CCC #5 MS element). At the beginning of the Elaborate phase, the ideas related to chemical reactions and explosions can be leveraged to introduce the Elaborate task which asks students to consider two types of reactions involving hydrogen, chemical combustion and nuclear fusion, as possible processes that can account for the scale of energy released by the Sun" (TM, page 35).
    - 5E2: "In middle school students learned that looking for patterns in data can help determine cause and effect relationships and that explanations of stability and change can be constructed by examining changes over time….listen for these ideas: Anticipated Student questions….What causes a star to change and explode? (CCC #1 MS) Are there patterns? (CCC #7 MS)" (TM, page 82).
    - 5E3: "In this phase, the idea that graphs and charts are useful for identifying patterns in data is an important middle school element of the CCC. Prompt students to think about how they can represent the data in order to more easily identify evidence of patterns. This will make it easier to foreground this element of Patterns at the end of this phase and build toward an important high school element of patterns during the Explore 2 and Explain 2 phases" (TM, page 140–141).
- The teacher is given information about how some of the student learning will progress after the unit: "Also, once students have filled in the writing scaffold, in later Earth and Space Science units they will learn how to use what they wrote in the boxes to construct a paragraph that explains the answer to the original investigative question, but in a way that ensures that all three parts are included in a coherent manner, thus supporting students in developing an understanding that scientific explanations are constructed in this way" (TG, page 36).
- Charts at the end of each 5E sequence list in which parts of the sequence (e.g., Explore, Explain) the learning goal elements are used. Descriptions of exactly how and where this learning

progresses for students were not found, although teacher notes frequently point out in each activity where students are meant to develop an idea or proficiency. For example, in 5E3, the teacher is told "Deriving a mathematical equation from data will support students in understanding the role mathematical representations play in allowing them to identify patterns that otherwise could not be identified. In this case allowing them to describe the pattern in the relationship between orbital period and average distance more accurately" (TM, page 151).

- Some mentions are made of potential student prior conceptions. For example, in 5E3: "All students have some background knowledge about why water exists in different phases, and this Engage phase is designed to support students in applying their existing intuitions to making sense of solar system data. Incomplete ideas are evidence of sensemaking (sic), and there will be plenty of opportunities for students to develop an accurate explanation of Comet Borrelly's behavior" (TM, page 138).

Suggestions for Improvement

- Consider describing the expected level of student proficiency for each of the targeted elements by the end of each 5E sequence and how students are building on the elements from lesson to lesson.

II.D. SCIENTIFIC ACCURACY

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

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

The reviewers found extensive evidence that the materials use scientifically accurate and grade appropriate scientific information because all provided information is scientifically accurate, materials use phenomena that are appropriate for high school 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 students' three-dimensional learning are accurate. For example:

- 5E Instructional Cycle 1, How the Sun Works, Explore: "Launch students into observing patterns in the spectra, then answering questions 1-2. While it may seem obvious that the Sun's light would be the same no matter when an observer is looking at it, this activity is important for highlighting the fact that we have *evidence* for this consistency. No matter when we observe the Sun, or the location from which we observe it, its spectra are consistent. The experience of looking at spectra data provides experience with citing empirical evidence for patterns, which students will build on in the coming parts of this instructional sequence when they use the patterns as evidence for a claim about the Sun's composition. The two prompts are designed to support students in developing the idea that empirical evidence is needed to identify a pattern (in this case a pattern in the Sun's spectra) and build toward a claim about the Sun's composition" (TM, page 40).

- 5E Instructional Cycle 2, Star Life Cycles, Evaluate: "Below are notes about what makes stars in the performance task data set either likely or unlikely to support a habitable planet. Trappist-1, Kepler 442, Kepler-18, Kepler-79, HD 17156, Kepler-186, HD 20782: These are Main Sequence stars that have a mass comparable to or less than our Sun, meaning they have life spans of 10 billion years or more and their properties are stable for 9 billion years or more. Therefore, if a planet orbits around one of these stars within the habitable zone, humans can settle there for a long time and plant and animal life may have had time to appear" (TM, page 118).

As a minor note, the anchor phenomenon "Earth is an Ideal Place to Support Life" is not a supported statement. There isn't evidence that Earth is ideal – just that it is habitable.

Suggestions for Improvement

Consider adjusting the wording of the anchor phenomenon.

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

The reviewers found extensive evidence that the materials provide guidance for teachers to support differentiated instruction. The unit contains many activities that provide suggested supports for multilingual learners, learners who read below grade level, struggling students, and students who have already met the performance expectations or one of the targeted elements of the three dimensions. However, few differentiation strategies or supports could be located for learners with disabilities.

In the Teacher Guide, supports and resources are given to help teachers develop accessible instruction and assessments customized for their students (e.g., TG, page 14). Some suggestions are provided in the Teacher Manuel (which describes instruction), but others are only in the Teacher Guide or in resources linked from the Teacher Guide.

Supports are provided to help multilingual learners, students who read below grade level, and students who need multi-modal supports to access instruction. For example:

- 5E1: “Using Domino Discover at this stage provides support for English Language Learners who are emerging and transitioning ELLs. Providing different types of unique comprehensible input, all from peers in the classroom, supports students’ language development” (TM, page 43).
- 5E1: “Students who are emerging and transitioning language learners benefit from the opportunity to work with images and repeated structure in this activity. Students who are expanding language learners have the opportunity to receive multiple types of input of ideas — in print and through others’ discussion. This supports their language development and access to engaging in science” (TM, page 49).
- 5E1: “We recommend you do NOT just let students read their claims aloud. Some classmates will need to see/read the claim to be able to follow up. A discussion with no visual component can leave out a number of students” (TM, page 53).
- 5E1: “Rather than assigning a list of vocabulary words—a technique that rarely works for learning new vocabulary—this activity allows language learners to learn vocabulary from context, which may be particularly helpful for transitioning language learners, who already have some mastery of language” (TM, page 54).
- 5E1: “Note that emerging English learners may need to do this task with additional support—verbally, in a home language, or some other way” (TM, page 60).
- 5E2: “Some English Language Learners and below level readers may struggle with fluency when reading this or other texts. Allow those students to use a device that has the Chrome extension Natural Reader Text to Speech, which reads the text aloud as it highlights the words. This will allow struggling readers to focus on comprehending important concepts instead of having to focus most of their efforts on reading fluently” (TM, page 100). Note that leveled text options are not provided.
- 5E2: “We recommend you have groups display their explanatory models while they share their ideas. A discussion with no visual component can leave out a number of students” (TM, page 104).
- 5E3: “For emerging language learners, hearing from classmates describing the activity they just completed and their findings provides comprehensible input that supports their language development. It also gives transitioning language learners an opportunity to rehearse and try out ideas in front of the class, which is more supportive than extemporaneous talk or cold calling” (TM, page 150).

- 5E3: “These two pages of the student materials include particularly dense text and introduce several tier three vocabulary terms. Consider providing small group instruction to multilingual learners and below grade-level readers. You can support them in navigating the text, by conducting a read aloud and prompting them to make connections between the written text being read aloud, diagrams, and the algebraic equation” (TM, page 162).

Supports are provided for struggling students. For example:

- Unit Launch: “It may be helpful for some students if you break down the steps for working independently. Have them read through the texts first, without writing. Then have them read through them a second time, with annotations either in the margin of the page or on a sticky note” (TM, page 15).
- Unit Launch: The teacher is given guidance to support students struggling to ask questions related to solving problems: “If this is the first time students have generated a Driving Question Board (DQB) they may struggle with coming up with appropriate scientific questions. If so, provide students with the Scaffolded Unit Questions for a DQB that can serve as an example or starting point. If using the scaffolded question set, encourage each individual or group to generate some questions on their own” (TM, page 19).
- 5E1: “It is critical that students’ struggle with the data is supported and not cut short. While it might be tempting to help students with completing the See-Think-Wonder or coming up with analyses, this will cut short their learning. Instead, use the pages in the student materials labeled ‘additional diagrams’ to provide a more concrete way to line up absorption lines. Students can even cut out the spectra for each element, to make it easier to visualize where things line up” (TM, page 43).
- 5E1: “If any students are struggling to get started with their scientific explanation, have students synthesize their learning about the Sun’s composition in a Claim-Evidence-Reasoning chart. Then have them use the ideas they capture in the organizer to write an explanation in paragraph form” (TM, page 52).
- 5E2: “Encourage students to write their explanations without an organizer, as it is likely that less students will need it at this time. The organizer should only be provided to students who are clearly still struggling to construct their explanations” (TM, page 60).
- 5E2: “Some students may struggle to articulate their observations in the data tables for this investigation. Support those students by including some sample student responses from below in their data tables, or using the sample student responses during conferring as models or examples” (TM, page 92).
- 5E3: “The Water in Our Solar System data table may be overwhelming for some students at first. Students who need more support can start with a smaller set of data (just Mercury, Earth, Jupiter, and Comet Borelly, for example). The teacher can also guide the text annotation work by asking questions…” (TM, page 136).
- 5E3: “Some students may have difficulty identifying relevant patterns in the solar system orbital data. Differentiate for these students by including sentence starters in the ‘See’ column of the See-Think-Wonder organizer that support them in identifying those patterns” (TM, page 144).

- 5E3: “As groups are working, support them with figuring out the mathematical model equation. It may be that some pairs need more one-on-one support with using the spreadsheet to create a model. See the Tip box below with guidance on this” (TM, page 152).

Extension activities are provided for students who have already met the targeted PE or element:

- Unit Launch: “Encourage students who have already written a strong argument to think about which planets could have an atmosphere and what the thickness and pressure of a potential atmosphere might be. This is not something that was explicitly covered in the Planets and Orbits 5E, but students can consider each planet’s proximity to its star and the planet's mass/gravity” (TM, page 25). This activity helps extend students’ DCI-related learning.
- 5E1: “If you have a real spectrometer in your classroom, challenge students that complete their explanations early and demonstrate mastery to investigate real samples of unknown gases with the real spectrometer and to determine the identity of each unknown based on their spectra. Have them share their claims with the rest of the class, prompting them to cite empirical evidence of patterns they used to identify the unknown gases if they don’t do so initially” (TM, page 52).
- 5E2: “If students complete their Explain handout early and demonstrate mastery, have them investigate why some stars did not fall on the main trend line by completing the Why do some stars not fall in the main trend line? handout found in the additional materials section at the end of this teacher guide” (TM, page 103).
- 5E3: “If students are able to demonstrate a complete understanding of why water exists in different phases on different celestial objects in our solar system and why water changes phases on Comet Borrelly, consider having them skip the Explore 1 and Explain 1 phases, which support the development of those explanations” (TM, page 139).
- 5E3: “If students complete the Elaborate phase early and demonstrate mastery, remind them that one of the questions the class had about exoplanets they are investigating is whether they have an atmosphere. Provide data for planets in our solar system, including diameter, mass, and density data of different planets. Challenge them to look for patterns in our solar system data associated with the existence of an atmosphere on planets in our solar system. They should see a pattern in the relationship between mass and existence of an atmosphere and diameter and the existence of an atmosphere. Encourage them to think about why these relationships exist and use those patterns to make claims about the existence of an atmosphere on exoplanets in the performance task data set” (TM, page 166).

Suggestions for Improvement

- To provide differentiation supports for learners with disabilities, consider the following:
    - Providing additional resources to support the development of mathematical concepts in the unit for teachers; and
    - Including supports to assist teachers with presenting abstract content in small incremental steps. Providing teachers with examples of how concepts such as hydrogen, chemical combustion and nuclear fusion can be broken down into smaller pieces of information for students to build upon throughout the unit would be helpful.

- To assist students with different reading levels, consider supports such as:
    - Spending more time on building background for the reading selections and creating a mental scheme for the organization of the text; and
    - Providing alternative text with varying reading levels or additional alternative texts and videos that could allow differentiation for those unable to access the text itself through the suggested differentiation strategies.

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 *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials support teachers in facilitating coherent student learning experiences over time because teacher support and strategies are provided for linking student engagement across lessons and for helping students see connections between their learning in all three dimensions and their sense-making.

The teacher is supported to understand and master the learning sequences. For example:

- Guidance is given to the teacher for approaching the unit and maintaining coherence: “The first time enacting Unit 1 with students may take longer than anticipated, particularly if the pedagogical approach is significantly different from what a teacher is used to. A teacher may want to skip entire lessons or activities, or revert to more traditional approaches when it seems like time is running out. We often ask teachers to think about the best way to modify recipes. Just like when using a recipe for the first time, it’s a good idea to stay as true to the materials as possible before making modifications or substitutions! As teachers become more familiar and comfortable with the instructional model, the embedded routines, and three-dimensional teaching overall, the desire to skip things will dissipate. Teachers using our curriculum over time have noticed that they are able to move a bit quicker through this and other NGSS-designed units every year!” (TG, page 9).

- The teacher is given the suggestion to work through the evaluate phase of each part of the unit before using it with students, which could increase coherence for students: "Completing major tasks and immersive experiences helps teachers to get a sense of what students need to do to be successful in a unit, and to anticipate students' struggles and misunderstandings" (TG, page 11). The teacher is then encouraged to make their own map of the unit based on what strategies might need extra emphasis for their students.
- A summary of each 5E Cycle, including what students do and what students figure out, is given to the teacher at the beginning of the Teacher Materials (TM, page 4).
- Facilitation guidance is given to the teacher to help make connections for students, linking each activity to the prior activities. For example, in 5E3, the teacher is told: "Frame the next activity for students: 'Now that we have established a mathematical representation of the relationship between a planet's average distance from its host star and orbital period, how can we use that to make a claim about objects orbiting other stars?' Have students share their thinking about applying what we figured out to other stars in the universe" (TM, page 155).
- As a minor note, there are some areas of potential confusion in the teacher directions, repeating directions more than once. For example, page 117 seems to repeat most of page 115.

Teachers' prompts are provided to facilitate student questions that will lead into future activities. For example:

- Unit Launch: "What do we need to investigate to find an Earth-like planet where humans and other species might be able to live? Think about your initial explanations for why planet Earth is the only planet in our solar system that has been habitable. Then generate questions you would like to further investigate to find another Earth-like planet. Have students independently come up with questions they would need to answer to understand if an exoplanet was Earth-like. Each question goes on a separate sticky note" (TM, page 18).
- 51: "Modify the list of student ideas about how the Sun works based on student responses. Return to student questions from the start of the 5E (the Engage), to bring up lingering issues not yet resolved, and new issues that have come up, such as: Are hydrogen and helium on fire in the Sun? Or is something else happening? Can gases burn? People talk about the Sun 'burning up'; does that mean it's burning?" (TM, page 54).
- 5E2: "Prompt students to work in pairs to generate questions that can frame the investigation of stars that could support an Earth-like planet" (TM, page 82).
- 5E2: "Tell students that they will now investigate their questions about how to determine if a star has a low mass and will have a long and more stable life, or if it is high mass and will have a less stable and shorter life span" (TM, page 92).
- 5E2: "Revisit the Driving Question Board questions and have students identify what they have figured out and what they still need to investigate" (TM, page 118).

The teacher is supported to help students connect their learning in the three dimensions to their sense-making. For example:

- Unit Launch/Performance Task: Students are asked: "How did thinking about patterns, scale, and stability & change help you make sense of the phenomena in this unit?" (TM, page 26). Students gather in small groups to discuss their thoughts in response to this question.
- 5E2: "Ask students to think about the data they want to collect as a way to support their engagement in the sensemaking process. If students are having trouble thinking about what data they want, prompt them to think about the Sun data they examined in the How the Sun Works 5E" (TM, page 84).
- 5E2: "But we figured out that we still have some questions about how and why we see these changes. This is a great example of how identifying patterns (like we did in the star graphs) helps us come up with new questions" (TM, page 99).

Suggestions for Improvement

Consider including additional teacher guidance and strategies for supporting students to see how their learning in all three dimensions connects to their sense-making and problem solving — especially for CCC learning.

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

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

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

The reviewers found extensive evidence that the materials support teachers in helping students engage in the practices as needed and gradually adjust supports over time because scaffolds are seen to decrease over time for almost all the targeted SEP elements. However, scaffolds often remain the same over time with class consensus, charts, and small group work used consistently between lessons.

Developing Models

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

- For this element, students are given some scaffolds at the beginning of the unit that are then not used again. For example:
    - Unit Launch: Students develop introductory models using a template: "Provide students with the Anchor Phenomenon: Initial Model handout and have students complete it independently or in pairs. Then have students work in groups of four to collaboratively develop an initial model for why Earth is the only planet in our solar system that has been habitable on poster paper" (TM, page 12). The teacher is given several areas of

guidance to help students with their models, such as "Are there arrows or labels you want to add to your drawing" (TM, page 12). The teacher is also told "This is the first time students have modeled why they think the Earth is habitable. The Earth-Sun System template is useful for steering students toward modeling at the scale of our solar system, which is the scale at which students will be investigating and modeling Earth's habitability throughout the unit. Moving forward, do not provide this template unless a student or group seems confused about how to start their revised versions of their model" (TM, page 12).

- 5E1: "Ask students to consider their responses to these questions and what they have figured out about how the Sun works, then represent their ideas about why the Sun has been able to support a planet where life has been able to exist and evolve on their initial group models from the performance task launch. These should go onto new pieces of chart paper. Facilitate student critique of one another's models through the Group Learning Routine Idea Carousel" (TM, page 63). The teacher is told "Using what they learned in the Idea Carousel, have students independently refine their models in their performance task research organizer" (TM, page 65). After students revise their models, the teacher is told "Have students work in pairs and use their understanding of how our Sun works to make predictions in relation to the following three questions:" [e.g.,] "What do you predict will happen to the amount of hydrogen over time? What evidence do you have for this?" (TM, page 68).
- 5E2: "Use student responses to decide how to depict the magnitude of the force of gravity vs. fusion force with arrows. In other words, draw arrows with a length that represents the relative magnitude of each force on the molecular cloud image in the Explain handout. Elicit student responses to demonstrate how to explain what is taking place in words. The class should arrive at an explanatory model that connects this early stage in a star's life to massive gravitational pull" (TM, page 101).
- 5E2: "Ask students to consider their responses to these questions and what they have figured out about how the Sun works, then represent their ideas about why the Sun has been able to support a planet where life has been able to exist and evolve on their initial group models from the performance task launch. These should go onto new pieces of chart paper. Facilitate student critique of one another's models through the Group Learning Routine Idea Carousel" (TM, page 113). The teacher is told "Allow groups to use peer feedback and ideas shared by other groups to go back and revise their model" (TM, page 114).
- 5E3: "Ask students to independently develop an initial model that explains the phenomenon" (TM, page 137).
- 5E3: The teacher is told "Tell students that they will now have an opportunity to use evidence of patterns in orbital data to revise their initial solar system models from the Engage phase" (TM, page 145).
- 5E3: "Using what they learned in the Idea Carousel, have students independently refine their models in their performance task research organizer" (TM, page 168).

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

- Students are supported to develop new knowledge about this element. For example:
    - 5E2: The teacher is told "Students may not have an understanding that computational models are based on real data. This is highlighted in paragraph one of the text on the first page of the investigation handout. Be sure to unpack this enough so that students know this model is based on evidence. This is particularly important, since they will be using data generated from this model to make evidence-based claims" (TM, page 87). "Students work through the investigation using Star in a Box model to collect data about each group of stars" (TM, page 88).
    - 5E3: "If students have never used Sheets or Excel to create graphs, it may be necessary to take time out for a tutorial at this point. It is important that students create and analyze graphs independently, as this is how they develop the practice of modeling" (TM, page 141).
    - SE3: The teacher is told "Share with students that…the whole point of coming up with these equations is being able to make predictions about other situations, where we don't have as much information" (TM, page 155). Students are then asked to "examine the orbital data below. Then complete the diagram by depicting where the orbits of Planet Zb, Planet Zc, and Planet Zd would lie with respect to Planet Za. Be sure to provide evidence and reasoning from the mathematical model above to support your claims" (5E3 SM, page 10).

Constructing Explanations

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

- Students are supported to use the first part of this element more independently through reduced scaffolding over time and explicit discussions about sources of evidence. Related evidence includes:
    - In the Teacher Guide, teachers are told "When formative assessment indicates students are reaching proficiency in completing explanations and arguments, encourage them to construct subsequent explanations and arguments without using the C-E-R scaffold" (TG, page 35).
    - The Teacher Manual says "The handout to the right can be a helpful scaffold for some students as they organize their ideas prior to writing a formal argument. Students should have experience with writing arguments in middle school, but some may still need additional support with incorporating their ideas from the organizer into a formal argument. If students can write an argument without starting with the organizer, allow them to do so" (TM, page 25).
    - 5E1: "If any students are struggling to get started with their scientific explanation, have students synthesize their learning about the Sun's composition in a Claim-Evidence-

Reasoning chart. Then have them use the ideas they capture in the organizer to write an explanation in paragraph form" (TM, page 52).

- 5E1: "Have students use the ideas surfaced from the data card sort and Class Consensus Discussion to develop an explanation for how the Sun releases energy. Students just constructed an explanation in the previous phase. Encourage students to write their explanations without an organizer, as it is likely that less students will need it at this (sic). The organizer should only be provided to students who are clearly still struggling to construct their explanations" (TM, page 60).
- Several parts of the unit support students to develop an understanding of sources of evidence for explanations (e.g., "What Counts as an Evidence-Based Claim?" on TM, page 46).

Suggestions for Improvement

N/A

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

CATEGORY III

MONITORING NGSS STUDENT PROGRESS

III.A. MONITORING 3D STUDENT PERFORMANCES

III.B. FORMATIVE

III.C. SCORING GUIDANCE

III.D. UNBIASED TASK/ITEMS

III.E. COHERENT ASSESSMENT SYSTEM

III.F. OPPORTUNITY TO LEARN

III.A. MONITORING 3D STUDENT PERFORMANCES

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

Rating for Criterion III.A. Monitoring 3D Student Performances	*Extensive* *(None, Inadequate, Adequate, 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 and design solutions to problems because student artifacts are routinely developed throughout the unit and require students to use the three dimensions to make sense of the phenomenon.

Related evidence includes:

- All the targeted learning is assessed in the unit, and there's a fairly close match between learning targets intended and those assessed (for exceptions, see evidence in Criterion III.C).
- Student tasks are focused on phenomenon-based scenarios, and often require all three dimensions to be used together.
- Students have frequent opportunities to create individual-level, observable artifacts of their performance. For example:
    - 5E2: Students collect data from a computational model (SEP: **Developing and Using Models**) of nucleosynthesis in stars (DCI: **PS3.D Energy in Chemical Processes and Everyday life**) in order to identify patterns (CCC: **Patterns**) in the relationship between mass of a star (**DCI: ESS1.A The Universe and Its Stars**) and nucleosynthesis (DCI: **PS3.D Energy in Chemical Processes and Everyday life**). "Have the groups complete a Think-Talk-Open Exchange to help students articulate their ideas. While students are sharing responses, have students work in pairs to complete the page Elaborate: How are elements heavier than iron produced? Use the Group Learning Routine, Domino Discover, to surface the thinking across the room. The class should arrive at the conclusion that a supernova explosion generates more energy than any star can, allowing for the fusion of the heaviest elements. Assess student understanding of CCC #1 Patterns independently by asking each student to respond to the prompt" (TM, page 111).
    - 5E3: Students use the evidence of patterns identified in graphs (CCC: **Patterns**) they created to revise their solar system models (SEP: **Developing and Using Models**) that explain water's phase change and stability on objects orbiting the Sun. They use their models to identify important features of the motions of orbiting objects (DCI: **ESS1.B: Earth and the Solar System**) that would allow a planet to maintain liquid water (TM, page 146).

Suggestions for Improvement
Consider increasing the frequency of support for students to use high school-level elements of CCCs in their tasks.

III.B. FORMATIVE

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

Rating for Criterion III.B. Formative	Extensive *(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 lesson level objectives. The informal assessment opportunities frequently provide guidance on how to shift instruction based on student understanding, and the formal assessment opportunities provide extensive guidance on what to look/listen for in student responses. However, these formal opportunities do not include guidance on how the teacher could shift instruction based on student understanding.

Formative assessment guidance is given frequently throughout the unit. For example:

- Unit Launch: As students share their initial thinking about the anchor phenomenon, students engage in group learning/discussion and the teacher is told: [this group activity] “allows students to learn from each other and for the teacher to assess whether the class is ready to move to the next phase of instruction” (TM, page 16).
- 5E1: “If students are having trouble arriving at some of the ideas above, use the suggested conferring questions at the right to support their sensemaking process” (TM, page 40).
- 5E1: “If students do not cite the numbers (wavelengths) under the black lines are the same in each spectra as empirical evidence of the pattern, ask them to cite evidence that the black lines are in the same place, as needing empirical evidence to identify patterns is an important element of CCC #1 – Patterns” (TM, page 40).
- 5E1: “This routine is an opportunity to surface students’ thinking to the whole class and the teacher. It allows students to learn from each other and for the teacher to assess whether the class is ready to move to the next phase of instruction” (TM, page 42). The teacher is given guidance about “possible things students may say that indicate emerging understanding.” Then the teacher is told: “If students don’t surface one or more of the observations above, display the Three Views Spectrum Demonstrator, the spectrum from the Sun and/or element gases and use the suggested conferring questions from this Explore phase to have students surface those

ideas. Once those observations are surfaced, the class is ready to move on to the Explain phase" (TM, page 43).

- 5E1: As directions for the summary task, the teacher is told "The results of this task can be used to make determinations about which students need more time to circle back to the ideas in this text in the coming parts of the 5E lesson" (TM, page 55). Here, student responses are used to determine individual-level supports.
- 5E1: "While students are engaged in the Idea Carousel, listen for the following ideas. Where needed, discuss with groups what is coming up in their models, to ensure these points emerge in the classroom" (TM, page 64). Here, student responses are used to determine small group-level supports.
- 5E2: "If students don't surface one or more of the observations above, display and run the Star in the Box simulation, using the suggested conferring questions from this Explore phase to have students surface those ideas. Once those observations are surfaced, the class is ready to move on to the Explain phase" (TM, page 91).
- 5E2: "If students don't surface one or more of the observations above, select one group's chart and use the suggested conferring questions from this Explore phase to have students surface those ideas. Once those observations are surfaced, the class is ready to move on to the Explain phase" (TM, page 96).
- 5E2: "The results of this task can be used to make determinations about which students need more time to circle back to the ideas in this text, in the coming parts of the 5E sequence" (TM, page 105).
- 5E3: "Use the answers in the Summary Task to make decisions about which ideas may need to be revisited or explored more in coming parts of this 5E Instructional sequence" (TM, page 148).
- 5E3: "The most important idea here is that the transit method allows us to determine how often a planet passes in front of a star. If this idea does not surface, show students the transit method graph below" (TM, page 150).
- 5E3: "Use the answers in the Summary Task to make decisions about which ideas may need to be revisited or explored more in upcoming parts of this lesson" (TM, page 160).
- Additional evidence related to teacher guidance for supporting struggling students is found in Criterion II.E.

At the end of each 5E sequence, students revisit the performance task to revise their model and explanation/argument. A complete rubric is provided showing indicators of different levels of student responses, allowing teachers to differentiate between levels of student understanding. Guidance for informing instruction based on these performance task revisions is not provided to the teacher. However, students are supported to self-evaluate using a rubric and reflect on their learning. For example:

- Unit Launch: "1) Remind students that one of the main themes of this unit has been evidence-based claims and that their final argument is one type of evidence-based claim. 2) Prompt students to identify how their thinking has changed about what counts as an evidence-based claim. Support student ideas by projecting the initial and final class lists of what counts as an evidence-based claim. 3) Have students discuss ideas in their groups. 4) Provide students with the Arguing from Evidence Rubric to complete individually. Let them know that it's important they reflect thoughtfully because arguing from evidence is a practice they will engage in again in subsequent units, so they develop proficiency to argue from evidence at the high school level" (TM, page 26).

- 5E1: "After students complete their work, support them to use the rubric for this learning sequence as a self-reflection tool" (TM, page 65).
- 5E2: "After students complete their work, support them to use the rubric for this learning sequence as a self-reflection tool" (TM, page 115).

Suggestions for Improvement

- Consider including teacher prompts for how instruction might be modified to react to the learning needs of individual students after each formal performance task.
- There are many areas in the unit where students discuss their learning process. Providing guidance related to using these discussions to formatively assess students could allow the instructor to better identify areas where students may need additional support or enrichment.

III.C. SCORING GUIDANCE

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

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

The reviewers found adequate evidence that the materials include an aligned rubric and scoring guidelines that help the educator interpret student performance. Rubrics are included to support the Evaluate phase in each 5E Instructional Cycle. However, they do not always provide enough interpretation information about student performance in each dimension such that the teacher would be able to modify instruction and provide feedback to students. In addition, assessment targets are not always clear, and there is a mismatch between some performance indicators and their assessment targets.

Assessment targets are present but somewhat unclear. For example, the targeted three dimensions are listed at the end of each 5E sequence rather than together with the scoring guidance. For informal assessment opportunities, teacher notes sometimes call out a specific element that is intended to be assessed, but most of the time the teacher supports focus solely on the category level descriptors (e.g., "Patterns").

Example student work is provided throughout the unit, (e.g., TM, page 13, TM, page 24, TM, page 40, TM, page 52, TM, page 60, TM, page 89, TM, page 102, TM, page 115, TM, page 156). Related evidence includes:

- Unit Launch: Two different levels of student work are included, one with reasoning and connections to CCCs and the other without (TM, page 24). However, there isn't evidence that the student work claimed to include CCC use includes high school-level CCC element use. Note that Grades 9–12 CCC element use isn't required here in the beginning of Unit 1, but without specifying the level, readers could assume that the high school unit elicits Grades 9–12 elements.
- 5E1: A sample student response is included that is meant to show an understanding of a targeted CCC element (*Empirical evidence is needed to identify patterns*). However, the sample student response shown does not include evidence of student use of this understanding, as students only mention evidence for the pattern rather than note that empirical evidence is required to identify a pattern (TM, page 40).

Scoring rubrics are provided throughout the unit. Related evidence includes:

- Throughout the unit, a performance task rubric is used (TM, page 26). Note that the guidance about repeating use of this rubric is somewhat unclear.
- 5E1: A modeling rubric is given to both teachers and students, although it only describes two levels of student performance (proficient and developing). A **Scale, Proportion, and Quantity** CCC element seems to be targeted, but the rubric description for "Proficient" doesn't show high school-level understanding of this element: "Either the model or a written explanation shows the relevance of scale of time: the length of time that Sun has been releasing the right amount of energy for liquid water to exist on Earth is sufficient time for life to evolve" (TM, page 65). However, an example student answer shows evidence of student use: "We think that when we investigate other phenomena, scale might be useful for knowing which possible processes to consider and which we can rule out as explanations for what we observe of the phenomena" (TM, page 66).
- 5E2: A modeling rubric is given to both teachers and students, although it only describes two levels of student performance (proficient and developing). A **Stability and Change** CCC element seems to be targeted, but the rubric description for "Proficient" doesn't show high school-level understanding of this element: "*Much of science deals with constructing explanations of how things change and how they remain stable*" (TM, page 115).
- 5E3: A modeling rubric is given to both teachers and students, and it represents all three dimensions (5E3 SM, page 16). However, it only describes two levels of student performance (proficient and developing).
- 5E3: An argument rubric is given to both teachers and students, and it represents all three dimensions (5E3 SM, pages 17–18). However, it only describes two levels of student performance (proficient and developing).

Suggestions for Improvement

- Consider clarifying assessment targets at the element level. This could include middle school-level elements used to gauge students' levels of prior understanding.
- Consider ensuring a match between performance descriptors and assessment targets.
- Consider including at least three levels of student performance in the teacher-facing rubrics.
- In student-facing rubrics, consider separating the explanation part of the rubric from the modeling part. This separation could help clarify for students the equal importance both explanations and modeling have.

III.D. UNBIASED TASK/ITEMS

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

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

The reviewers found extensive evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples. The identified tasks that are used to measure student learning are developmentally appropriate. However, students are not given a choice of modality for expression.

Related evidence includes:

- Students are supported with scaffolds to ensure they can be successful with each task. For example, formal assessment modalities (modeling and explanation/argumentation) are scaffolded early in the unit with teacher notes to continue to provide these scaffolds if students need them later.
- Tasks often involve multiple modalities (for example, drawing [e.g., TM, page 101], writing [e.g., TM, page 68], graphing [e.g., TM, page 141], and mathematical equations [e.g., TM, page 151]) to present students' ideas.
- An opportunity for student choice of modality of response was not seen in the formal assessment tasks.
- Each Instructional Cycle concludes with students returning to the Performance Task Packet where students can revise their models or explanations. These formal assessment tasks all require writing (some also include other modalities in addition to writing, but not as a choice instead of writing), meaning that students not strong in writing may not be able to fully express their understanding.

Suggestions for Improvement

- Consider providing teachers with strategies that will support students to represent their understanding in different ways during formal assessments.
- Consider providing students with choices of modality of expression during formal assessments.

III.E. COHERENT ASSESSMENT SYSTEM

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

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

The reviewers found extensive evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.

Support is provided to help teachers understand the system of assessments:

- "Unit 1 targets a bundle of three PEs taken from the first core idea in high school Earth and Space Science (ESS1), Earth's Place in the Universe; those standards are HS-ESS1-1, HS-ESS1-3 and HS-ESS1-4. This PE bundle informs the types of three-dimensional tasks in which students engage across the unit. Each sequence of lessons within the unit targets elements from one or more of the performance expectations for the unit, and the teacher has opportunities to collect evidence of student learning around these elements within that learning sequence. The unit-level Performance Task only targets a subset of three-dimensional learnings goals informed by the bundled PEs for the unit. All other evidence of learning related the other dimensions/elements in the PEs can be found within the instructional sequences. The Teacher Materials for each sequence of lessons includes a matrix that lists which student artifacts can provide evidence of student learning for each of three-dimensional learning goals from that sequence" (TG, page 18).
- An Assessment Table is provided to teachers showing which learning goals are assessed in which part of the unit, but only categories of each dimension are shown (e.g., "Patterns" versus a specific **Patterns** CCC element) (TG, page 19).

Pre-Assessment:

- The unit is intended as the first unit in high school, and is connected to prior learning from middle school:
    - Teacher Guide: "It is helpful to consider the middle school standards in order to enact a unit that builds on students' prior experiences. As we are in the middle of a multi-year transition, however, it is also critical to keep in mind that not all students will have

experienced an NGSS-designed unit when they come to high school, so the process of building on middle school learning may be particularly complex for years to come" (TG, page 7). Middle school-level elements from all three dimensions that are needed as prior learning are also listed.
  - 5E1: "Students have background knowledge that can be used to drive the investigation. Listen for the following ideas related to energy and its conservation that students grappled with in middle school…." (TM, page 35).
  - 5E2: "In middle school students learned that looking for patterns in data can help determine cause and effect relationships and that explanations of stability and change can be constructed by examining changes over time….listen for these ideas: Anticipated Student questions….What causes a star to change and explode? (CCC #1 MS) Are there patterns? (CCC #7 MS)" (TM, page 82).
- Some teacher notes during the unit provide additional support related to pre-assessment. For example, in 5E1 the teacher is told "this discussion is a great opportunity to elicit and document students' current thinking about evidence and argumentation" (TM, page 46).

Self-Assessment:
- Unit Launch: Students are supported to self-evaluate using a rubric: "1) Remind students that one of the main themes of this unit has been evidence-based claims and that their final argument is one type of evidence-based claim. 2) Prompt students to identify how their thinking has changed about what counts as an evidence-based claim. Support student ideas by projecting the initial and final class lists of what counts as an evidence-based claim. 3) Have students discuss ideas in their groups. 4) Provide students with the Arguing from Evidence Rubric to complete individually. Let them know that it's important they reflect thoughtfully because arguing from evidence is a practice they will engage in again in subsequent units, so they develop proficiency to argue from evidence at the high school level" (TM, page 26).
- 5E1: "After students complete their work, support them to use the rubric for this learning sequence as a self-reflection tool" (TM, page 65).
- 5E2: "After students complete their work, support them to use the rubric for this learning sequence as a self-reflection tool" (TM, page 115).
- 5E3: "After students complete their work, support them to use the rubric for this learning sequence as a self-reflection tool" (TM, page 168).

Formative: See related evidence under Criterion III.B.

Summative:
- The teacher is told that "the Unit 1 Performance Task also includes a final argument rubric, and the task can be considered a summative assessment for the unit; for that reason, there is no traditional 'unit test' in our materials. Teachers may opt to create a final exam using their state's previous exam questions; however, we believe that the formative assessment tasks embedded in the materials (such as the Looks and Listen For notes, the Explain phase summaries, and the

modeling done in the Evaluate phases), along with the Performance Task can serve as sufficient evidence of what students know and can do" (TG, page 19).

Suggestions for Improvement

Consider including information about how teachers can make use of the information they receive during formal assessment opportunities.

III.F. OPPORTUNITY TO LEARN

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

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

The reviewers found extensive evidence that the materials provide multiple opportunities for students to demonstrate performance of practices connected with their understanding of core ideas and crosscutting concepts. Students have multiple opportunities to revise and improve their performance on most of the targeted learning, reflecting on and applying peer feedback received along the way to construct new learning. Students can regularly show their growth in understanding within lessons through iterative modeling activities and through Performance Task Organizer lessons. However, students do not have explicit opportunities to receive feedback from the teacher.

Related evidence includes:

- There are iterative student performances that provide students with the opportunity to demonstrate their growth in proficiency over time. For example:
  - 5E1: "After students complete their work, support them to use the rubric for this learning sequence as a self-reflection tool" (TM, page 65).
  - 5E2: Using questions that emerged from the previous 5E Instructional Sequence, students investigate more about the properties of stars (investigative phenomenon) that could simulate the relationship Earth has with the sun (TM, pages 78–81). At the end of the instructional sequence, students return to models and explanations created in the unit launch (performance task organizer) to revise and add to their new learning (TM, pages 113–119).
  - 5E3: Students return to the anchor phenomenon and DQB and turn their focus to the category of questions focused on temperature and the existence of liquid water on the exoplanets (TM, pages 135–139). After investigating orbiting objects students return to

models and explanations created in the unit launch (Performance Task Organizer) to revise and add to their new learning (TM, pages 166–168).

- Students have multiple opportunities to receive and apply peer feedback. For example:
  - 5E1: "Allow groups to use peer feedback and ideas shared by other groups to go back and revise their model" (TM, page 64).
  - 5E1: "Assign students to partnerships and have them review one another's work and self-assessment and provide feedback on the accuracy of the self-assessment. Give each student an opportunity to revise their model using what surfaced from their self-assessment and/or feedback" (TM, page 65).
  - 5E2: "Mix up the student pairs, so that students are in triads with people they have not worked with on the Fe-26 game. Have the groups complete a Think-Talk-Open Exchange to help students articulate their ideas in response to questions. Here students will share with others and gain feedback on their ideas by finding similarities and differences" (TM, page 110).

Suggestions for Improvement

For all focal learning goals in the unit, consider including explicit opportunities for students to demonstrate understanding, then receive feedback from the teacher, then revise and demonstrate new understanding.

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

SCORING GUIDES FOR EACH CATEGORY

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

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)