# Matter Cycling and Energy Transfer in Lake Ecosystems

**DEVELOPER:** Carolina

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

Educators Evaluating Quality Instructional Products

NextGen Science WestEd

# Matter Cycling and Energy Transfer in Lake Ecosystems

## EQuIP RUBRIC FOR SCIENCE EVALUATION

**OVERALL RATING: E**

**TOTAL SCORE: 9**

| CATEGORY I: NGSS 3D Design Score | CATEGORY II: NGSS Instructional Supports Score | CATEGORY III: Monitoring NGSS Student Progress Score |
|---|---|---|
| 3 | 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 | Extensive | **A.** | Monitoring 3D Student Performances | Extensive |
| **B.** | Three Dimensions | Extensive | **B.** | Student Ideas | Extensive | **B.** | Formative | Adequate |
| **C.** | Integrating the Three Dimensions | Extensive | **C.** | Building Progressions | AdequateAdequate | **C.** | Scoring Guidance | Adequate |
| | | | **D.** | Scientific Accuracy | Extensive | **D.** | Unbiased Tasks/Items | Extensive |
| | | | **E.** | Differentiated Instruction | Extensive | | | |

**Summary Comments**

Thank you for your commitment to students and their science education. This lesson scored highly on the EQuIP rubric lesson-level criteria and is very strong in many ways. For example, all students are provided with opportunities to observe and ask questions about the phenomenon throughout the lesson. They have multiple opportunities to reflect on their sense-making as well as their learning in all three dimensions throughout the lesson. Students also have many opportunities to engage in three-dimensional learning, the teacher is provided with guidance to make the learning locally relevant to students, and students have multiple opportunities to express their ideas and give and reflect on peer feedback.

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

- **Providing guidance to help teachers and students distinguish between different levels of performance for CCCs**. Currently, the scoring guidance focuses mostly on students' progressing levels of DCI understanding. Providing the same level of guidance for CCCs could ensure that both the students and teacher can assess student's proficiency in all the dimensions.
- **Clarifying assessment targets for individual assessments**. Currently, it is somewhat unclear which elements of each of the three dimensions are targeted in particular assessments. Explicitly clarifying the assessment targets that include specific elements of all the dimensions assessed could be helpful.
- **Describing learning progressions within the lesson.** Currently, the progression of learning is mainly explicit for DCI elements and there's little detail available about how students will learn each targeted SEP and CCC element during the lesson.

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.

# CATEGORY I

# NGSS 3D DESIGN

## I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

## I.B. THREE DIMENSIONS

## I.C. INTEGRATING THE THREE DIMENSIONS

## I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

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

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

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

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

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

The reviewers found extensive evidence that learning is driven by students making sense of phenomena or designing solutions to a problem. The fish kill phenomenon is introduced to students at the beginning of the lesson, and the focus of each investigation is to support students in making sense of this phenomenon. Student questions are elicited at the beginning of the lesson and are used to motivate sense-making for each investigation.

The phenomenon that tens of thousands of fish died in summer 2012 along the Lake Erie shoreline is introduced to students in the Phenomenon section of the student guide (Student Guide, page S–1). Students work through three investigations to develop an explanation for this phenomenon. Related evidence includes:

- The investigative phenomenon is described in the teacher guide as “a fish kill that occurred in Lake Erie in late summer” (Teacher Edition, page 3). A focal driving question is listed at the beginning of the lesson, “What changes in the lake ecosystem caused the fish to die?” (Teacher Edition, page 1).
- Students are introduced to the phenomenon through both text and photos in their student guide (Student Guide, page S–1). The digital resources also include a slide show of additional photos that can help students observe the phenomenon.
- Students have an opportunity to make observations and develop questions about the phenomenon (Student Guide, pages S–2 and S–3). Students work individually to construct an initial explanation of the causes of fish dying in the lake pulling on their own experiences with aquatic ecosystems and their prior knowledge (Student Guide, page S–3).
- At the end of Investigation 1, students develop their initial models for a balanced lake ecosystem and identify what may have changed in the system resulting in an unbalance and ultimately the fish kill (Student Guide, page S–10). They also construct an explanation “for how changes in one or more components of the lake ecosystem caused it to become unbalanced and

led to the fish kill" (Student Guide, page S–11). Students are asked to reflect on what they have figured out so far and how the "information you gathered from the reading about matter cycling and energy flow in ecosystems help you better understand the phenomenon?" (Student Guide, page S–12).

- At the end of Investigation 2, students revise their models from Investigation 1 (Student Guide, page S–18). They are also asked to construct an explanation for how the changes in the levels of nutrients caused changes in the lake ecosystem that contributed to the fish kill event (Student Guide, page S–19). Students are asked to reflect on what they have figured out so far and how "nutrient pollution causes changes in matter cycling and energy transfer in the lake ecosystem" (Student Guide, page S–20).
- The launch for Investigation 3 states: "To drive sense-making, students should make connections between the phenomenon and the investigation" (Teacher Edition, page 61).
- After Investigation 3, students develop their final model that "predicts how changes in components of the system caused it to become unbalanced and led to the fish kill" (Student Guide, page S–27). As their final performance task, they also "construct an explanation for how changes in abiotic and biotic components of a lake ecosystem caused changes in matter cycling and energy transfer and led to a fish kill" (Student Guide, page S–28).

Student questions are elicited throughout the lesson and guidance is provided for how teachers can use student questions to drive learning for each investigation. Students have opportunities to return to the driving question board (DQB) to see what questions they have answered and to add any additional questions. Evidence includes:

- In the beginning of the lesson, the teacher is told that students will use a DQB throughout the lesson. "Dedicate a space in your classroom—such as a bulletin board, wall, or whiteboard—for your class DQB…. Because the DQB will be revisited throughout the lesson, it's important that it be displayed in the classroom where it is visible to students…. Have students generate their own questions first, then share with a group and collaboratively sort the questions into categories with an overarching theme, such as questions about plants, questions about animals, questions about energy (light and temperature), etc. Then, use themes in categories seen across all groups to create a class DQB. Each theme should have an overarching question and sample student questions that encompass the range of student thinking and ideas across the class. Establish a need for students to engage with each investigation by connecting it to the category from the class DQB that relates to the investigation" (Teacher Edition, page 14). The teacher is also told that the DQB should be explicitly revisited after each investigation in the lesson "so that unanswered or new questions can serve as the transition into the next investigation."
- In the Student Guide, Question #1 in the Engaging in the Phenomenon section asks students to "record general questions they have about the phenomenon" (Student Guide, page S–2).
- In the Student Guide, Question #3 in the Engaging in the Phenomenon section asks students to work with a partner to develop two or three questions to investigate the causes of changes to the lake ecosystem (Student Guide, page S–3). They are asked to think about what they wonder about the phenomenon that would help them explain the causes (Student Guide, page S–3).

- In the Launching the Phenomenon section, Steps #6–10 provide guidance for how to set up the Driving Question Board and how to organize student questions (Teacher Edition, page 21).
    - The teacher is told that "student questions will be based on their observations of the phenomenon from the article, photos, and slide show" and to "encourage students to ask additional questions based on their own experiences with similar phenomena and exposure to aquatic ecosystems" (Teacher Edition, page 21).
- Investigation 1: "The goal of the launch is to select driving questions on the DQB that can be addressed directly through the investigation and reading. Before class, review Investigation 1 and Reading 1 — Matter Cycling and Energy Transfer in Ecosystems in the Student Guide. Identify questions on the DQB that can be answered with the data and information students will be able to obtain from the investigation and reading" (Teacher Edition, page 27). The teacher is then told to revisit the DQB with students, facilitating them to focus on questions related to Investigation 1.
- Investigation 1: At the end of the Investigation, the class revisits the DQB and students identify which questions they were working on, which questions they are able to answer, and what additional questions they have (Student Guide, page S–12).
- Investigation 2: At the beginning of the investigation, the teacher is told: "Before class, review Investigation 2, the digital investigation resources, and Reading 2 — Nutrient Pollution in the Student Guide. Identify questions on the DQB that can be addressed with the data and information students will be able to obtain from the investigation and reading. With your class, revisit the DQB and focus the class on questions related to the growth of algae and causes of algal blooms. The DQB should have some questions related to algal growth based on student observations during the launch of the phenomenon and information from Reading 1 on nutrients. … Guide students toward choosing a question about nutrients and how they might affect algal growth" (Teacher Edition, page 47).
- Investigation 2: At the end of the investigation, the class revisits the DQB and students identify which questions they were working on, which questions they are able to answer, and what additional questions they have (Student Guide, page S–20).
- Investigation 3: At the beginning of the investigation, the teacher is told: "The goal of the launch is to select driving questions on the DQB that can be addressed directly through the investigation and reading. Use the following prompts to initiate a discussion and guide students toward selecting questions around changes in temperature and energy inputs to the lake ecosystem" (Teacher Edition, page 61).
- Investigation 3: "Revisit the DQB and ask students which questions they were able to answer based on evidence they have gathered so far. If any questions remain unanswered, encourage students to conduct further research using information obtained from a reliable source" (Teacher Edition, page 63).

Prior experiences about the phenomenon are elicited. Evidence includes:

- In Launching the Phenomenon, Step #5 says "ask student pairs to share their experiences with aquatic ecosystems. It is important that students make connections using their own experiences

with elements of the phenomenon in order to relate to it and motivate their sense-making" (Teacher Edition, page 19).

- When creating the DQB, Step #9 instructs the teacher, "Encourage students to ask additional questions based on their own experiences with similar phenomena and exposure to aquatic ecosystems" (Teacher Edition, page 21). "Think about your own experiences with aquatic ecosystems of different scales and types, including freshwater and marine. Consider the organisms you observed, the scale and boundaries of the system, and why the system might be an important resource to the local community. Pair up with one of your classmates to discuss your experiences and create a list of insights that might be helpful in making sense of the Lake Erie phenomenon" (Student Guide, page S–2, Teacher Edition, page 22). The teacher is told "It is important that students make connections using their own experiences with elements of the phenomenon in order to relate to it and motivate their sense-making. Your students will have experiences with aquatic ecosystems of different scales including aquariums, ponds, streams, rivers, lakes, oceans, and estuaries. Some example student experiences are provided in the Sample Responses section (see page 23). Ask students to identify analogous phenomena in the aquatic systems they have experienced" (Teacher Edition, page 22).

***Suggestions for Improvement***

N/A

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

The reviewers found extensive evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions relative to the length of materials. Students have opportunities to develop and use most of the claimed SEP, DCI, and CCC elements during the lesson.

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

The reviewers found extensive evidence that students have the opportunity to use or develop most of the claimed SEP elements in the lesson.

The following SEP elements are claimed as learning targets in each lesson, but the activities in which the elements are intended to be used are not specified. Detailed below is evidence of full or partial use of the elements:

**Asking Questions**

- *Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.*
    - This element is claimed on page 4.
    - Launching the Phenomenon: Students make observations of the phenomenon and work with a partner to develop "two or three questions to investigate the causes of changes to the lake ecosystem" (Student Guide, page S–3). Guidance is provided to the teacher for how to group and organize the questions (Teacher Edition, page 21), but students are not explicitly told to ask questions that can be investigated within the scope of the school laboratory, etc., so they do not engage with this high school-level element.
    - Investigation 2: Students are asked: "With your group, construct a hypothesis, based on the experimental data, for how nutrient levels could affect algal populations in the lake ecosystem. … What other questions would need to be answered to support or refute your hypothesis?" (Teacher Edition, page 52)
    - Investigation 3: Students use the first part of this element when the teacher is told to "use the prompts below to guide students toward revising questions that can be investigated using the materials available in the laboratory" and then students are asked to share their questions for class feedback, during which the teacher is told to provide additional guidance to help them revise questions so that they are investigable (Teacher Edition, pages 61–62).

**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.*
    - This element is part of one of the claimed "building toward" PE learning goals of the lesson and is explicitly claimed on page 4.
    - Investigation 1: Explain Question #2 asks students to "develop an explanatory model that shows the relationships between plants and animals in a closed system" using the evidence from the data they gathered (Student Guide, page S–9).
    - Investigation 1: Students develop an initial model "that illustrates the interrelationships among components of the lake ecosystem" and to "use it to predict how the system became unbalanced and led to the fish kill" (Student Guide, page S–10). Students are asked to draw components of the ecosystem, arrows to depict the interactions and

relationships between components of the system, processes, inputs/outputs, and boundaries. Students are told to draw upon the data from the investigation and reading. They are also asked to identify components of a system that could change and cause the system to become unbalanced leading to the fish kill.

- Investigation 2: Students revise their initial models from Investigation 1 (Student Guide, page S–18). Students are told to add additional components of the ecosystem and to make any other revisions to their initial components and relationships. Students are told to draw upon the data from the investigation and reading.
- After Investigation 3, students complete their final models by revising the model they have been working on during previous investigations (Student Guide, page S–27). Students are told to add additional components of the ecosystem and to make any other revisions to their initial components and relationships based on evidence from their investigations and readings.
- Lesson Reflection: Students are asked to respond to the questions "(a) How would you describe a scientific model? (b) How has your thinking about models changed over the course of this lesson? (c) How did you use your model of the lake ecosystem to develop your explanation of the causes of change to that ecosystem?" and "(a) What are some limitations of your final model of the lake ecosystem? (b) As you developed your model, you made decisions about which components you would include. Describe how you decided which components to include in your model and which to not include. (c) How could you improve your final model of the lake ecosystem?" (Student Guide, page S–29, Teacher Edition, page 72).

**Planning and Carrying Out Investigations**

- *Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.*
    - This element is claimed on page 4.
    - Investigation 1: Students engage with portions of this SEP category in preparation of designing their own investigation later in the lesson. In steps #1–2, the teacher discusses ways for the students to develop an investigation on a small-scale using bromothymol blue and other materials (Teacher Edition, page 28). The teacher is told to discuss the values and drawbacks of isolating a component in a small-scale closed system to gather data to use as evidence. Other discussion prompts in the investigation also support students in thinking about this SEP concept, such as "What other variables could influence the processes happening in the tube systems? Predict how changing the temperature variable could alter your results, then justify the reasoning behind placing the systems in the same location for both investigations" (Teacher Edition, page 29).
    - Investigation 3: Students choose a question to investigate that will help them figure out the effect of light/temperature on the components of the lake ecosystem. They plan their investigation collaboratively and the Investigation Planning Template asks them to

identify the research question, hypothesis, independent variable, dependent variable, control group, controlled variables, materials, set-up, and procedures (Student Guide, pages S–22 to S–25). It also asks them to consider confounding variables and how they will address them in their design to ensure that all variables are controlled. Students then use the data produced from their investigation as evidence for their Final Model (Student Guide, page S–27) and Final Explanation (Student Guide, page S–28).

**Using Mathematics and Computational Thinking**

- *Use mathematical representations of phenomena or design solutions to support claims.*
    - This element is part of one of the claimed "building toward" PE learning goals of the lesson.
    - Investigation 2: Students graph data and then describe patterns in their data (Teacher Edition, pages 51–52). They are told "Make a claim about how nutrient levels affect algal populations in the closed test tube systems. Support your claim with evidence based on patterns in the data" (S–17, page 52).

**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.*
    - This element is part of one of the claimed "building toward" PE learning goals of the lesson.
    - In the beginning of the lesson, students are asked to construct an initial explanation of the phenomenon and are given a table to complete with columns for evidence and reasoning. They are also asked to "reread the article again and underline or highlight evidence that supports your explanation. Also recall evidence you observed in the slide show. In addition, use evidence from your own experiences with aquatic ecosystems and knowledge from prior learning" (Teacher Edition, page 24).
    - Investigation 1: Students are asked to "construct an explanation for how changes in one or more components of the lake ecosystem caused it to become unbalanced and led to the fish kill." They are also asked to specifically list "lines of evidence supporting my explanation: Evidence from experiments __ Evidence from the readings and other reliable sources __" etc. (Student Guide, page S–11, Teacher Edition, page 42).
    - Investigation 2: Students are asked to "construct an explanation for how changes in levels of nutrients caused changes in matter cycling and energy transfer in the lake ecosystem that contributed to the fish kill event." They are also asked to specifically list lines of evidence supporting their explanation: "Evidence from investigation __ Evidence from the readings and other reliable sources __" etc. (Student Guide, page S–19, Teacher Edition, page 56).
    - Investigation 3: As their final performance task, students are asked to "construct an explanation, based on evidence, for how changes in abiotic and biotic components of a

lake ecosystem caused changes in matter cycling and energy transfer and led to a fish kill." They are also asked to specifically list lines of evidence supporting their explanation: "Evidence from investigations __ Evidence from the readings and other reliable sources of information __" etc. (Student Guide, page S–28, Teacher Edition, page 70).

- The last part of the claimed element ("*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")* is not explicitly discussed or used in the lesson.

The Features of this Lesson to Support NGSS Instruction section states that "most importantly, the students are given a series of investigations and articles that contribute to the students' abilities to engage in the practice of developing an argument for how the evidence they gathered supports the explanation they constructed for the causes of algal blooms and related fish deaths in lakes" (Teacher Edition, page 13). However, no elements from the **Engaging in Argument from Evidence** SEP category are claimed as learning targets in the lesson. When students complete the reflection questions after Investigations 1 and 2 (Student Guide, pages S–12 and S–20), they are most likely engaging with the Grade 6–8 **Constructing Explanations** SEP element: *Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.*

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

The reviewers found extensive evidence that students have the opportunity to use or develop the claimed DCI elements in this lesson. Students develop most of this claimed learning and use it in service of sense-making.

The following DCI elements are claimed in the lesson:

**PS3.D: Energy in Chemical Processes**

- *The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.*
  - This element is part of one of the claimed "building toward" PE learning goals of the lesson.
  - This idea is explicitly stated in Reading 1 (Student Guide, page S–30, Teacher Edition, page 103).

**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems**

- *Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.*

- This element is part of one of the claimed PE learning goals of the lesson and is explicitly claimed on page 4.
- Students begin to build an understanding of this element. Some evidence includes:
  - Investigation 1: Students begin to build an understanding of this element through the assigned reading: *Reading 1 – Matter Cycling and Energy Transfer in Ecosystems*. The reading describes a food web, trophic levels, how matter and energy move through trophic levels, and how available energy and matter decrease in each trophic level (Student Guide, pages S–30 to S–33).
  - Investigation 1: Explain Question 2 asks students to show the relationship between producers and consumers in a closed system, including processes, inputs and outputs of matter and energy, and evidence that verifies the inputs and outputs of the processes (Student Guide, page S–9). The sample student answer describes the inputs (light energy, water, dissolved carbon dioxide) and outputs (oxygen and glucose sugar) of photosynthesis along with the formula $6CO_2+6H_20$ $C_6H_{12}O_6+60_2$ as well as the inputs and outputs of cellular respiration along with the formula $C_6H_{12}O_6+60_2$ $6CO_2+6H_20$ (Teacher Edition, page 39). They are also asked to "show or describe how matter and energy are conserved in your model."
  - Investigation 1: In the Performance Task, students are asked to "construct an explanation for how changes in one or more components of the lake ecosystem caused it to become unbalanced and led to the fish kill" (Student Guide, page S–11). The descriptor of grade-level appropriate responses indicates that students should discuss how carbon dioxide and oxygen are cycled between producers and consumers in the lake ecosystem and what happens when this relationship becomes unbalanced (Teacher Edition, page 43).
  - Investigation 2: The assigned reading *Reading 2 — Nutrient Pollution* describes how nutrient levels can affect the cycle of matter in a lake ecosystem.
  - Investigation 3: The assigned reading *Reading 3 — Abiotic Factors* describes how the movement of oxygen in the lake ecosystem can be affected by abiotic factors.
  - Students use their understanding of this element when developing and revising their models for the phenomenon at the end of each investigation and when writing their explanations for the performance tasks.

- *Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.*
  - This element is part of one of the claimed "building toward" PE learning goals of the lesson. Also, the DCI box on page 30 states that "while not claimed as a focus, this lesson builds toward portions of another high school target for LS2.B…"
  - This idea is explicitly stated in Reading 1 (Student Guide, page S–31, Teacher Edition, page 104).

- *Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.*
    - This element is part of one of the claimed "building toward" PE learning goals of the lesson.
    - A footnote on page 4 also states this element, although with portions crossed out. The portions crossed out in the footnote are not developed in the lesson, even though the entire element is claimed in the PE learning goals.

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

The reviewers found extensive evidence that students have the opportunity to use and develop the claimed CCC elements in this lesson relative to the length of the materials.

**Systems and System Models**

- *Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions — including energy, matter, and information flows — within and between systems at different scales.*
    - This element is part of one of the claimed "building toward" PE learning goals of the lesson.
    - Investigation 1: Students create models, including energy and matter flows, therefore supporting their learning of this element: "Because mapping both energy flow and matter cycling in the same model may result in a complex model, encourage students to use creative approaches such as creating two separate models: one for energy flow, and another for matter cycling. The example student model uses different colors of arrows to trace the movement of matter and energy among components of the model" (Teacher Edition, page 32).
    - Investigation 2: Students are asked to "revise your model of the lake ecosystem to include additional boundaries, inputs, outputs, and interactions" (Student Guide, page S–18, Teacher Edition, page 54).
- *When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.*
    - This element is claimed on page 4.
    - Parts of this element are first introduced in the Engaging in the Phenomenon section. In Question #1, students are told to "Observe the before and after photos and record your observations about the initial conditions of the lake, and the changes that occurred around the time that dead fish were found" (Student Guide, page S–2). Then, in Question #2, students are asked to think about their own experiences with aquatic ecosystems of different scales and are asked to think about the scale and boundaries of the system (Student Guide, page S–2).
    - Investigation 1: In the Stop and Think questions, students are asked to think about the experiment as a system and are asked to identify the boundaries, inputs, outputs

(Student Guide, page S–4). It is not clear whether students understand that these components of a system *need* to be defined (other than to be able to answer question a.i. on Student Guide, page S–4). The test tube set up serves as a small-scale model for part of the larger lake ecosystem. They are asked to think about how the conditions of the small-scale system change over time. Students are also told to record the initial conditions of the solution in each tube (Student Guide, page S–5).

- Investigation 1: Students are asked to think about the lake ecosystem as a system when developing their models (Student Guide, page S–10). The teacher is told to stress that students should develop a model for a balanced system and then identify what may have changed to cause the system to become unbalanced (Teacher Edition, page 28). Students identify the boundaries, inputs, and outputs of the system when developing their models.
- Investigation 1: On Student Guide, page S–6, the question "What is the purpose of using the rubber stopper in the small-scale system?" implicitly encourages students to consider the inputs and outputs in a system, but it is not certain that all students will make that connection. Discussion Prompts for the teacher after Investigation 1 may get students thinking about how manipulating variables would influence the outcomes of their experiment, such as "What other variables could influence the processes happening in the tube systems?" (Teacher Edition, page 29). Students are also asked in Stop and Think Question C to consider how the design of the investigation addressed any confounding variables (Student Guide, page S–7). These prompts may result in some students using the CCC element, but it isn't clear that all students will use it here.
- Investigation 1: In Explain Question #2, students develop a model that shows the relationship between producers and consumers in a closed system, identifying components of the system including processes, inputs and outputs of matter and energy, and evidence that verifies the inputs and outputs of the processes (Student Guide, page S–9).
- Investigation 2: In the first step of the procedure, students are asked to identify the initial conditions of the tube system (Student Guide, page S–15).
- Investigation 3: Students are asked to list the steps to setting up the experiment and how they will collect data, including about the initial conditions of the small-scale systems and how they will gather evidence of changes over time (Student Guide, pages S–23 and S–24). Then, when students create tables to collect data and observations to use as evidence, the sample student answer shows students listing "initial conditions" before the observation for each test tube (Teacher Edition, page 67).
- In their Final Models, students make their final revisions to their models to explain the phenomenon of what led to the fish kill event (Student Guide, page S–27, Teacher Edition, page 100). Students are asked to show the interactions among the components of the ecosystem, including the inputs and outputs of matter and energy into the system, how energy and matter are moving through the system, and to identify the boundaries of the system.

  - Lesson Reflection: Students are asked to respond to the question "How has your understanding of systems changed throughout the course of this lesson? Provide at least one example." (Student Guide, page S–29, Teacher Edition, page 72).
- *Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.*
  - This element is not claimed in the lesson but seems to be the focus of student reflection questions at the end of the lesson: "(a) What are some limitations in gathering evidence from small-scale systems to investigate the causes of changes in larger systems? (b) What are some advantages of using small-scale systems to investigate the causes of changes in larger systems?" (Student Guide, page S–29, Teacher Edition, page 72).

**Energy and Matter**

- *Energy drives the cycling of matter within and between systems.*
  - This element is part of one of the claimed "building toward" PE learning goals of the lesson.
  - The lesson includes a lot of emphasis on energy flows and matter cycles, but not on the idea that it is energy that *drives* the matter cycles. For example, Reading 1 says "The processes that drive the movement of energy and matter in ecosystems include photosynthesis and cellular respiration" (Student Guide, page S–30, Teacher Edition, page 103). It is therefore unlikely that students would develop this CCC element during the lesson.
- *Energy cannot be created or destroyed — it only moves between one place and another place, between objects and/or fields, or between systems.*
  - This element is part of one of the claimed "building toward" PE learning goals of the lesson.
  - Investigation 1: When creating their models, students are asked to "Show or describe how matter and energy are conserved in your model" (Student Guide, page S–9, Teacher Edition, page 38). However, this performance more closely shows student understanding of a different CCC element: *The total amount of energy and matter in closed systems is conserved*.
  - This idea is explicitly stated in Reading 1 (Student Guide, page S–31, Teacher Edition, page 104).
  - Lesson Reflection: Students are asked to respond to the question "How has your understanding about the cycling of matter and transfer of energy in ecosystems changed as a result of this lesson?" (Student Guide, page S–29, Teacher Edition, page 72).

***Suggestions for Improvement***

**General**

The lesson states that it is "building toward" some PEs, but it is likely that educators will assume that means that students will have proficiency in the PEs by the end of the lesson. Consider clarifying which

learning goals will be accomplished by the end of the lesson and which will be further developed in future learning experiences.

**Science and Engineering Practices**
N/A

**Disciplinary Core Ideas**
In the lesson, students learn most of the targeted DCIs through readings, which are connected to sense-making of the anchor phenomenon and answering student questions. The targeted DCIs are not the only ideas necessary to make sense of the phenomenon, however. It could be helpful to clarify that this lesson provides a foundation for student understanding of many other DCI elements, such as those related to chemical reactions and ecosystem carrying capacity.

**Crosscutting Concepts**
Consider supporting students to develop an explicit understanding of the high school level CCC elements such that they could use them independently in other 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<br>*(None, Inadequate, Adequate, Extensive)* |

The reviewers found extensive evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena. Learning is generally multi-dimensional in the lesson, and students have several opportunities to use all three dimensions together in service of making sense of the anchor phenomenon.

Related evidence includes:

- Investigation 1 Explain Question #2: Students develop a model to show the relationship between producers and consumers (Student Guide, page S–9). Students use a **Developing Models** SEP element, part of a **Systems and System Models** CCC element, along with some prior DCI understanding from middle school. They are asked to then circle or name the components of the system that, if changed, could help them explain the cause of the fish kill.
- After completing Investigations 1 and 2, students are asked to use the evidence they have gathered so far to develop and then revise their lake ecosystem model (Student Guide, pages S–

10 and S–18). Students use a **Developing Models** SEP element, a **Systems and System Models** CCC element along with DCI understanding from **LS2.B** to make sense of the phenomenon.

- Investigation 3: Students are asked to "identify a relationship in your model that would help you address one of the driving questions about the cause of the freshwater lake becoming unbalanced," develop a research question to investigate, plan their investigation, and write how they will collect data, including the initial conditions of the small-scale systems and how they will gather evidence of changes over time (Student Guide, pages S–21, S–23, and S–24). Then, when students create tables to collect data and observations to use as evidence, the sample student answer shows students listing "initial conditions" before the observation for each test tube (Teacher Edition, page 67). Students use a **Planning Investigations** SEP element with part of a **Systems and System Models** CCC element to gather evidence (related to DCI **LS2.B**) they can use to explain the lake ecosystem phenomenon.
- At the end of the lesson, students develop their Final Models and explanations for the phenomenon of why the freshwater lake system became unbalanced (Student Guide, pages S–27 and S–28). Students use a **Developing Models** SEP element, part of a **Systems and System Models** CCC element, and parts of the **LS2.B** DCI element, along with prior knowledge from middle school when they revise their models and then use them to construct their final explanation.

***Suggestions for Improvement***

Expanding opportunities for students to use high school level CCC elements as discussed in Criterion I.B would increase student use of grade-appropriate, three-dimensional performances.

| **OVERALL CATEGORY I SCORE:**<br>**3**<br>(0, 1, 2, 3) | |
|---|---|
| **Lesson Scoring Guide – Category I** | |
| **Criteria A–C** | |
| **3** | Extensive evidence to meet at least two criteria and at least adequate evidence for the third. |
| **2** | Adequate evidence to meet all three criteria in the category. |
| **1** | Adequate evidence to meet at least one criterion in the category but insufficient evidence for at least one other criterion. |
| **0** | Inadequate (or no) evidence to meet any criteria in the category. |

# CATEGORY II

## NGSS INSTRUCTIONAL SUPPORTS

## II.A. RELEVANCE AND AUTHENTICITY

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

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

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

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

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

The reviewers found extensive evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world. Students experience the phenomenon fish kill event in Lake Erie together as a class, and suggestions for how to make the phenomenon more locally relevant to students are provided. While establishing questions for the DQB, students are asked to consider their own experiences and what insights might be helpful to make sense of the phenomenon.

Students experience the phenomena as directly as possible. Related evidence includes:

- The student guide introduces the phenomenon (thousands of fish dying) to students through words and comparative pictures (live fish in May and dead fish in late August) (Student Guide, page S–1, Teacher Edition, page 20). The teacher is told "Access the digital resource, 'Investigative Phenomenon: Lake Ecosystems,' and project the slide show of lake photos before and after changes in stability. Give students time to jot down their observations of each photo" (Teacher Edition, page 21).

The phenomena and activities are relevant for students. Related evidence includes:

- The brief scenario that is included in the phenomenon introduction text provides clear reasons for why students should care about the phenomenon (i.e., because the fish are "economically important"). "Declines in the yellow perch population and other important fish species such as lake trout could lead to a loss of jobs for families who depend on the fishing industry as a source of income" (Student Guide, page S–1).
- The Tips for Making the Phenomenon Locally Relevant section identifies four resources that can help with finding local occurrences for fish kills or algal blooms to make the learning more relevant and local for students (Teacher Edition, page 13). For example: "The North American Lake Management Society (NALMS) has state chapters that may be contacted for information about local occurrences. ... If you live in a coastal region, local newspapers carry stories about

marine algal blooms, red tides, and fish kills. These phenomena lend themselves to the high school level because they have multiple causes and are connected to changes at a global level."

- The Launching the Phenomenon section explains that the investigative phenomenon can be modified to a local lake ecosystem to make it more relevant for students (Teacher Edition, page 21). "If you choose to use a local lake ecosystem as the phenomenon, you will need to modify how you launch it with your students by providing local newspaper articles, photos, or bringing in a guest speaker."
- Students have opportunities to make observations, share their related prior experiences, and use prior knowledge about aquatic ecosystems to develop questions they'd like to investigate related to the given phenomenon as they build the class DQB (Student Guide, pages S–2 and S–3). Since some of these questions are based on their prior experiences, and some of the questions drive student learning, students may have opportunities to connect their explanation of the phenomenon to questions from their own experiences. For example:
    - In Launching the Phenomenon, Step #5 tells the teacher, "ask student pairs to share their experiences with aquatic ecosystems. It is important that students make connections using their own experiences with elements of the phenomenon in order to relate to it and motivate their sense-making" (Teacher Edition, page 19). It also asks students to "identify analogous phenomena in the aquatic systems they have experienced." Students are told to "think about your own experiences with aquatic ecosystems of different scales and types, including freshwater and marine. Consider the organisms you observed, the scale and boundaries of the system, and why the system might be an important resource to the local community. Pair up with one of your classmates to discuss your experiences and create a list of insights that might be helpful in making sense of the Lake Erie phenomenon" (Student Guide, page S–2).
    - When creating the DQB, Step #7 instructs the teacher, "Encourage students to ask additional questions based on their own experiences with similar phenomena and exposure to aquatic ecosystems" (Teacher Edition, page 21). Some of the sample questions provided on page 25 show a connection to prior experiences.
    - Several suggestions are given for analogous phenomena that students might have encountered before: "Students will have varying experiences with freshwater and marine ecosystems. If some students have not, ask them to think about other systems such as freshwater or marine aquariums. You may have an aquarium in your classroom or somewhere in the school. If so, this would be a great place to begin having students share. Students may have observed similar or analogous phenomena such as algae growing in a bucket of water left outside; algae growing in an aquarium tank; fish dying in an aquarium system; algal blooms in small ponds; and beach closings due to red tide, harmful algal blooms, or pollution" (Teacher Edition, page 23).

***Suggestions for Improvement***

After students explain the phenomenon (e.g., the end of the lesson), consider adding opportunities for students to connect their explanations of the phenomenon to a problem or question from their own experience.

## 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. Many of the opportunities focus on students participating in class discussions and group activities, but students also have multiple opportunities to make their thinking visible through individual activities and to receive and reflect on feedback from both the teacher and peers.

General strategies to help elicit student ideas are provided in the teacher guidance materials. Some examples include:

- The Speaking and Listening Skills section describes strategies that are used in the lesson to help students work collaboratively (Teacher Edition, page 17). This is a helpful resource for the teacher as it explains the purpose of each strategy. Strategies include Think-Pair-Share, Discussion Prompts, and a Poster Session. In each investigation, teachers are given several discussion prompts to foster student conversation and push thinking.
- The Lesson Performance Expectations section lays out what student artifacts are created for each targeted lesson performance expectation (Teacher Edition, page 5).
- Students are provided Student Guides where they can record their models, explanations, ideas, etc. as they work through the investigations in the lesson.

Students have multiple opportunities to express, clarify, and represent their ideas. Students participate in class discussions and group activities and generate individual student artifacts throughout the lesson. Some examples include:

- Launching the Phenomenon: Students have an opportunity to record their observations individually and engage in a think-pair-share strategy to discuss their initial ideas about the phenomenon (Teacher Edition, page 21). Students share these observations and questions with the class. These questions are revisited and revised in the beginning and end of each investigation (Student Guide, page S–12). After students make observations about the phenomenon, the teacher is prompted to “ask student pairs to share their observations and initial questions aloud. As they share, write the observations on the board. Every observation and question should be valued. If a student calls out something that is not an observation (inference, claim, comment, etc.), ask clarifying questions to tease out the actual observation and write that on the board” (Teacher Edition, page 21).

- Investigation 1: Students individually record their thoughts about the reflection questions and discuss them in groups and as a class (Teacher Edition, page 32).
- Investigation 2: Students complete Explain questions #1 to #3 on their own and then share their answers in groups (Teacher Edition, page 49).
- Investigation 3: Students work in groups to prepare a research poster to share the design and results of their investigation (Teacher Edition, page 63). A digital alternative is also suggested: "As a digital alternative, consider having students prepare a presentation slide, including photos or videos they may have taken during the investigation" (Teacher Edition, page 63).
- Investigation 3: At the end of the investigation, the teacher is told: "Assign the Reflection questions to evaluate how thinking and understanding changed through the course of the lesson. Encourage students to revisit the performance tasks as evidence of their learning" (Teacher Edition, page 63).
- Lesson Reflection: Students are asked to reflect on their learning: "How has your thinking about models changed over the course of this lesson?" "As you developed your model, you made decisions about which components you would include. Describe how you decided which components to include in your model and which to not include. How could you improve your final model of the lake ecosystem?" "How has your understanding of systems changed throughout the course of this lesson? Provide at least one example." "How has your understanding about the cycling of matter and transfer of energy in ecosystems changed as a result of this lesson?" (Teacher Edition, page 72).

Students have several opportunities to receive and reflect on peer and teacher feedback. Some examples include:

- Investigation 1: Explain Phase Steps #2 and #3, students individually complete the Explain questions in their Student Guide (Teacher Edition, page 30). The teacher organizes students into small groups so that they can discuss their answer, seek feedback, and gather additional evidence. Students are encouraged to revise their answers based on peer feedback.
- Investigation 2: "First, have groups review their initial models and use data and information they obtained from the reading to add new components and, if necessary, revise current components and relationships. Provide plenty of time for groups to exchange ideas and agree upon the revisions and how changes in components affect other components" (Teacher Edition, page 51).
- Investigation 3:
    - Students are told: "Complete the Investigation Planning Template and share it with your teacher and peers for feedback, making any agreed-upon changes before proceeding" (Student Guide, page S–21, Teacher Edition, page 60).
    - Then in Explore Phase Step #2, students share the question they want to investigate for class feedback (Teacher Edition, page 62). The teacher is also told to provide additional guidance if needed to help students revise their questions so that they are investigable. This provides students with an opportunity to receive and most likely reflect on both peer and teacher feedback. The teacher then verifies that the student groups have adequately completed the investigation template and signs off before they can

continue. This provides students with a chance to receive and most likely reflect on teacher feedback (if they do not receive a sign-off) (Teacher Edition, page 62).

- When groups present their research posters/slides, the teacher gives students three copies of a Peer Feedback Form. "Have students fill out a Peer Feedback Form for at least three other presentations" (Teacher Edition, page 63). The feedback form includes prompts such as "How well did the research question guide the design of the investigation? Provide evidence to support your answer" and "How well were the explanations supported by evidence from patterns in the data? Provide evidence to support your answer" (Student Guide, page S–26, Teacher Edition, page 99).
- The teacher is also told to "play the role of student and complete a peer review form for each group" (Teacher Edition, page 63).
- After the poster session, the teacher gives each group the feedback forms for their presentations: "Have groups review their forms and record any feedback that provides additional information to use as evidence to revise their models and explanations" (Teacher Edition, page 63).

***Suggestions for Improvement***

N/A

## II.C. BUILDING PROGRESSIONS

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

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

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

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

The reviewers found adequate evidence that the materials identify and build on students' prior learning in all three dimensions because some prior student learning is described at the element level. However, not all learning goals have prior learning or learning progressions described.

Related evidence includes:

- The lesson introduction (Teacher Edition, page 3) states that it is an introductory high school biology unit, so teachers can assume that the unit builds on middle school prior knowledge but no prior high school knowledge.

- The Progression from Middle School section includes the DCI, SEP, and CCC elements from the 6–8 grade band that are expected as prior learning (Teacher Edition, page 12). This section also includes a column for "How this Lesson Builds on the Element." This information is provided for three DCI elements, one SEP element, and one CCC element. Only one of the three focal SEP elements for the lesson (as claimed on page 4) has prior learning listed in this chart. In addition, the content in the column "How this Lesson Builds on the Element" doesn't describe how the middle school understanding is built upon; instead, it simply describes high school level learning goals in two rows and describes high school-level student activities in the other three rows. Students' progression from the middle school understanding in the first column to the high school performance in the second column is not delineated.
- In the beginning of each section (e.g., page 27) there are descriptions of "what students will figure out" that focus solely on DCI-related understanding, indicating that the learning progression focus is on DCIs.
- Launching the Phenomenon: Students write and discuss their initial explanations of the phenomenon (Student Guide, page S–3) and the teacher is instructed to "have pairs share their initial explanation of the phenomenon and facilitate a discussion to review prior knowledge about ecosystems" (Teacher Edition, page 23). The teacher is given discussion prompts to assess current understanding about ecosystems and is told "you will be able to gauge how student understanding has progressed from the middle school DCIs listed on page 12."
- Investigation 1: The teacher is told to "leverage students' prior learning (see Progressions from Middle School on page 11) by using the discussion prompts that follow" (Teacher Edition, page 27). Students prior learning of cellular respiration and photosynthesis can be gathered through the provided discussion questions.
- Investigation 1: Initial Model and Investigation Performance Task Step #4 instructs the teacher to visit each group as they work on their initial models to review their progress and make notes on their current understanding (Teacher Edition, page 32). They are told this is a good way to assess prior knowledge and understanding and that it will help them determine student understanding of part of the **Developing and Using Models** SEP and the **System and System Models** CCC.
- Investigation 2: Explore Phase Step #2 states to use the provided discussion prompts to activate prior learning about the role of chloroplasts and chlorophyll in photosynthesis (Teacher Edition, page 48).
- Investigation 1: A pop-out box about addressing misconceptions students may have is provided (Teacher Edition, page 35).

***Suggestions for Improvement***

- Consider describing progressions of learning in the "How this Lesson Builds on the Element" column on page 12 for all three dimensions.
- The following Grade 6–8 DCI element could be identified as required prior learning on page 11. **MS.LS2.A** could be explicitly built upon and connected to throughout the lesson: *In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or*

*other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.*

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

The reviewers found extensive evidence that the materials use scientifically accurate and grade appropriate scientific information. The content and readings in the lesson are accurate and grade appropriate. For example:

- On page 15, the materials recommend the teacher read the Research section of the Student Guide, which "provides science readings that serve as reliable sources of information for students to use as evidence to develop their models and support their explanations of the phenomenon."
- Investigation 1: A pop-out box about addressing misconceptions students may have is provided (Teacher Edition, page 31).

Two minor issues with accuracy were noted:

- Investigation 1: There is a minor scientific inaccuracy related to the nature of evidence. In the Formative Assessment Guide, the following is listed as evidence "From experimental data: The rates of photosynthesis and cellular respiration affect the levels of dissolved $CO_2$ and $O_2$ in the lake ecosystem. The data provided evidence that algae use $CO_2$ at the same or greater rate than they produce it in the presence of light. In the dark, the data showed that algae produce only $CO_2$ through cellular respiration. Consumers and decomposers always use $O_2$ and produce $CO_2$. $CO_2$ and $O_2$ are cycled between photosynthesis and cellular respiration" (Teacher Edition, page 43). However, this excerpt describes *analysis* of evidence rather than evidence itself (e.g., color changes or not in different conditions). Note that evidence is described accurately elsewhere in the lesson.
- A few places in the lesson describe the nature of data incorrectly. For example, in an Investigation 3 sample response: "Our data showed that increases in light intensity and temperature increase the rate of photosynthesis…" (Teacher Edition, page 65). Although this wording is not given to students, it may give teachers a misleading idea of what data are. Data cannot "show" explanations — they can be analyzed to provide evidence for explanations.

Elsewhere in the lesson this distinction is shown accurately (e.g., "Patterns in class data for Investigation 3 provide evidence that…" page 71).

***Suggestions for Improvement***

Consider clarifying the minor issues noted related to the nature of data and evidence.

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

The reviewers found extensive evidence that the materials provide guidance for teachers to support differentiated instruction. The materials provide supports for reading, writing, speaking, and listening skills as well as support for students who are above or below expected proficiency. However, guidance is not provided to help teachers identify students struggling with CCCs or to support those students in reaching CCC proficiency.

The Instructional Support section identifies and describes strategies to support reading, writing, speaking, and listening skills (Teacher Edition, pages 16–17). The section states that these strategies will address the needs of multilingual learners, students who read below grade level, and struggling students. Support for using these strategies is embedded throughout the lesson. For example:

- Lesson Introduction: When discussing uses of the word wall, the materials tell the teacher "Encourage students to include pictures of physical examples of each word where appropriate" (Teacher Edition, page 16). This strategy can support emerging multilingual students.
- Lesson Introduction: Strategies are given for how to frame and support the reading assignments for "students who struggle with reading and students who read below grade level" (Teacher Edition, page 16).

- Investigation 1: "An interactive digital resource titled 'Energy Flow and Matter Cycling' is provided to support multilingual learners, students with special needs, and students who read well below the grade level. This resource presents the concepts from the reading through the use of videos, slide shows, and interactive questions that provide opportunities for practice and remediation" (Teacher Edition, page 29).

Support for students who perform below the expected proficiency level is provided in the scoring guides for the Performance Tasks. The scoring guides include a Differentiation Strategies section that provides the teacher with guidance in adapting instruction if the students perform below the expected level of proficiency. This guidance is included in the Investigation 1 Performance Task (Teacher Edition, page 43), Investigation 2 Performance Task (Teacher Edition, page 57), and the Final Performance Task (Teacher Edition, page 71). These supports appear at key learning opportunities where additional sense-making guidance is important. For example:

- Investigation 1: In the "Formative Assessment and Differentiation Guide," guidance is given to support students struggling with models "Assign the digital resource, 'Initial Model Practice,' for remediation. This interactive activity contains a map of an initial model example" (Teacher Edition, page 43).
- Investigation 2: In the "Formative Assessment and Differentiation Guide," guidance is given to support students who display partial or limited understanding (mostly related to the DCI): "Interactive digital activities for remediation are provided with this product. Have students complete: (a) Review: Photosynthesis and Respiration, (b) Tutorial: Decomposers, and (c) Quick Check: The Relationship Between Photosynthesis and Respiration. Have students create a flow chart on chart paper that depicts how runoff leads to fish dying from DO depletion. Encourage them to use photos, drawings, and descriptions" (Teacher Edition, page 57).
- Investigation 3: In the "Formative Assessment and Differentiation Guide," guidance is given to support students who display partial or limited understanding of cause-and-effect relationships related to the DCIs (Teacher Edition, page 71). The remediation seems to target CCC proficiency, but only supports students to use the Grade K–2 level element, *Events have causes.*

A few extensions are provided for students who show evidence of proficiency. Some examples include:

- The scoring guide for Investigation 1 Performance Task includes an extension of learning for students who display a full understanding (Teacher Edition, page 43). Researching another ecosystem and developing a model for how energy and matter cycle through that system could help students deepen understanding of some DCIs.
- The scoring guide for the Investigation 2 Performance Task includes an extension of learning for students who display a full understanding (Teacher Edition, page 57). The extension suggests having students create a dynamic simulation for carbon cycling and energy flow in the lake ecosystem and builds toward the high school CCC elements as it helps students understand the role of simulations in modeling.
- The scoring guide for the Final Performance Task includes two extensions of learning for students who display a full understanding (Teacher Edition, page 71). Integrating pH changes in the lake ecosystem can help students explain the phenomenon at a deeper level. Researching

and finding examples of fish kills in ocean ecosystems and comparing them to the Lake Erie fish kill can also help deepen understanding of some of the DCIs. This extension also builds toward a high school-level **Cause and Effect** CCC element: *Changes in systems may have various causes that may not have equal effects.*

***Suggestions for Improvement***

- Consider providing suggestions for how instruction can be modified if students show varying levels of proficiency for expected prior knowledge.
- Consider providing additional reading and writing alternatives or providing students with the option to respond using different modalities.
- Consider providing suggestions to support students with various disabilities.

| **OVERALL CATEGORY II SCORE:**<br>**3**<br>(0, 1, 2, 3) | |
|---|---|
| **Lesson Scoring Guide – Category II** | |
| **Criteria A–E** | |
| **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 four criteria, including A |
| **1** | Adequate evidence for at least two criteria in the category |
| **0** | Adequate evidence for no more than one criterion in the category |

# CATEGORY III

## MONITORING NGSS STUDENT PROGRESS

## 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 DCIs and CCCs to make sense of phenomena or design solutions. Student artifacts of multi-dimensional learning are produced several times in the lesson for key targeted learning and each dimension is used in service of sense-making. Overall, almost all of the targeted learning is assessed in the lesson. However, the elements of the three dimensions that are intended for each individual assessment are not clear.

Related evidence includes:

- The Student Guide is a place where all students have a chance to record their ideas, answers, explanations, and models, and it provides the teacher with artifacts to assess for student understanding. For example, in Investigation 1: "Use sustained silent writing to have individual students complete the Explain questions in the Student Guide. Question 1 provides a writing scaffold for Claim–Evidence–Reasoning work" (Teacher Edition, page 30).
- Investigation 1: In Explain Question #2, students develop a model to show the relationship between producers and consumers (Student Guide, page S–9). Students use a **Developing Models** SEP element, part of the **Systems and System Models** CCC element, along with some prior middle school-level DCI understanding. They are asked to then circle or name the components of the system, that if changed, could help them explain the cause of the fish kill.
- After completing Investigations 1 and 2, students are asked to use the evidence they have gathered so far to develop and then revise their lake ecosystem model (Student Guide, pages S–10 and S–18). Students use a **Developing Models** SEP element, a **Systems and System Models** CCC element along with DCI understanding related to **LS2.B** to make sense of the phenomenon.
- Investigation 3: Students are asked to "identify a relationship in your model that would help you address one of the driving questions about the cause of the freshwater lake becoming unbalanced," develop a research question to investigate, plan their investigation, and write how they will collect data, including the initial conditions of the small-scale systems and how they will gather evidence of changes over time (Student Guide, pages S–21, S–23, and S–24). Then, when students create tables to collect data and observations to use as evidence, the sample student answer shows students listing "initial conditions" before the observation for each test tube (Teacher Edition, page 67). Students use a **Planning Investigations** SEP element with part of the **Systems and System Models** CCC element to gather evidence related to DCI **LS2.B** they can use to explain the lake ecosystem phenomenon.

- At the end of the lesson, students develop their Final Models and explanations for the phenomenon of why the freshwater lake system became unbalanced (Student Guide, pages S–27 and S–28). Students are expected to use a **Developing Models** SEP element, **Systems and System Models** CCC element, and parts of the **LS2.B** DCI element, along with prior knowledge from middle school when they revise their models and then use them to construct their final explanation. However, in these final models, students are still prompted explicitly to "Identify and label/describe processes, inputs and outputs, and boundaries" (Student Guide, page S–27, Teacher Edition, page 100), indicating that they are not expected to independently understand and apply the related CCC element on their own without prompting: *When investigating and describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.*

***Suggestions for Improvement***

Consider ensuring that assessments require students to use the high school level of all targeted elements of the three dimensions.

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

The reviewers found adequate evidence that the materials embed formative assessment processes throughout that evaluate student learning and inform instruction. The materials identify formative assessment opportunities throughout the lesson and provide some support in how teachers can modify instructional plans based on student responses, especially for Investigation 1. However, the guidance does not include formative assessment checks for all key learning experiences or guidance for instructional modifications based on different kinds of student responses.

Related evidence includes:

- The Remediation Guidance for Formative Assessment Checkpoints section states that opportunities for formative assessment and remediation are indicated in the Student Guide with a checkmark (Teacher Edition, page 15). This section identifies where in Investigation 1 these checkpoint locations are along with the dimensions that are being formatively assessed, what students should be able to do, and some remediation guidance. Additional guidance and correct student answers are provided for some of the prompts in the individual investigation pages. Out of the four checkpoints, one assesses a SEP element, one assesses part of a CCC element, and

two assess parts of a few DCI elements. Formative assessment checks for one of the key SEP **Developing Models** element, are not provided. In addition, this formative assessment information is not provided for Investigations 2 and 3.

- Investigation 1: The Stop and Think Questions are identified as a formative assessment check for CCC understanding (Student Guide, pages S–4 and S–5). "Have students complete the Stop-and-Think questions in the investigation individually. Use sustained silent writing as a strategy to focus the entire class on writing…These questions may be used as a formative assessment to gauge student understanding of the crosscutting concept, Systems and System Models" (Teacher Edition, page 28). Students are asked "Describe the boundaries, initial conditions, and living/nonliving components of the system" (S–4, page 26). However, it is not clear whether students understand that these components of a system *need* to be defined (other than to be able to answer question a.i. on Student Guide, page S–4). Therefore, a teacher would get limited information about students' understanding of the CCC element solely from students' answers to this prompt.
- Investigation 1 Part A: Stop and Think Question A is identified as a formative assessment check for DCI understanding (Student Guide, page S–6). A correct student answer is included on page 35.
- Investigation 1 Part B: The teacher is told to discuss the three Stop-and-Think questions for Part B and to use this as a formative assessment check to gauge student understanding of investigation design before they conduct their own investigation in Investigation 3 (Teacher Edition, page 29). The teacher is told to "provide a quick review about variables and controls, if needed," and some discussion prompts that can be used as remediation are included. A correct student answer is included on page 37. Discussion prompts are included as instructional modifications.
- Investigation 1: Explain Question #2 is identified as a formative assessment opportunity for DCI understanding (Student Guide, page S–9). The teacher is told that this question will help gauge students' current thinking about the relationship between photosynthesis and cellular respiration (Teacher Edition, page 30). A correct student answer is included on page 39, and discussion prompts that can be used as a remediation strategy are included on page 31. While discussion prompts are included as instructional modifications, guidance, or strategies to inform instruction based on specific student responses are not provided.

- Formative Assessment and Differentiation Guides for the Performance Tasks throughout the lesson include a "Descriptors of Grade-Level Appropriate Responses" column and an "Differentiation Strategies" column that provide the teacher with support in what to look for in student responses and how to adapt instruction depending on whether the students are above or below the expected level of proficiency. These scoring guides provide explicit guidance for the teacher for informing instruction based on student responses. Some examples include:
  - The scoring guide for the Performance Task in Investigation 1 includes two remediation options the teacher can use if students display limited or partial understanding as well as an extension option for those with full understanding (Teacher Edition, page 43). This

guide helps formatively assess DCI understanding and provides a remediation strategy if students are struggling with modeling. Explicit guidance related to CCCs is not included.
    - The scoring guide for the Performance Task in Investigation 2 includes two remediation options the teacher can use if students display limited or partial understanding (Teacher Edition, page 57). While this guide helps formatively assess DCI understanding, the extension activity appears to focus on the SEP: "This resource has a tutorial that walks users through the process of building models and using them to make predictions" (Teacher Edition, page 57). Explicit guidance related to CCCs is not included.
- Investigation 1: When students work on their initial models, the teacher is instructed to visit each group, review their progress, and make notes on their current understanding (Teacher Edition, page 32). Step #4 states that "this is a good way to assess prior knowledge and current understanding of the science concepts. The initial model will also help you determine student understanding of models, and the crosscutting concept of system models, including inputs, outputs, boundaries, and scale." However, guidance or strategies for what to look for in student responses or how to inform instruction based on student responses are not provided.
- Guidance for supporting students to think about their own learning is included. Some examples include:
    - The Reflection questions given to students at the end of each investigation provide students with an opportunity to interpret their own progress (Student Guide, pages S–12 and S–20). The Reflection questions in the Elaborate section ask students about developing and using models, systems and system models, and matter and energy (Student Guide, page S–30).
    - After Investigation 3, students are asked to work collaboratively to "prepare a research poster to share the design and results of their investigation" in order to share information and exchange feedback about "student investigations, results, and conclusions" (Teacher Edition, page 63). Students receive copies of the Peer Feedback Form (Student Guide, page S–26) and are asked to fill it out for at least three other presentations. After the poster session, groups then review their feedback forms and record any feedback that they can use to revise their models and explanations. This gives students the ability to reflect on their own progress.

***Suggestions for Improvement***

- For the formative assessment checkpoints, consider adding more explicit support for modifying instruction based on student responses, especially for Investigations 2 and 3.
- Consider adding some supports for shifting instruction based on different levels of sample responses.
- Consider adding formative assessment checkpoints and guidance that helps teachers assess student understanding of the targeted SEP **Developing Models** element.

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

The reviewers found adequate evidence that the included aligned rubrics and scoring guidelines help the teacher interpret student performance for all three dimensions. The lesson provides exemplar student responses in most cases and some interpretive scoring guidance, but it does not differentiate interpretation between the three dimensions, such that teachers would be supported to distinguish between students missing some understanding of CCCs and students missing some understanding of DCIs, for example. In addition, specific elements of the three dimensions that are targeted by scoring guidance are not made clear, although three-dimensional assessment targets are provided.

Related evidence includes:

- Exemplar student answers are included for all student work pages in the Student Guide. However, it is sometimes unclear which element(s) are targeted by the answers.
- In the Instructional Support section, the Scoring Guidance for Student Models section states that scoring guides are provided for "the initial model, model revision, and final model" and describe that these are scored on four attributes "to assess their progress in the targets for all three dimensions" (Teacher Edition, page 14). The Scoring Guides (Teacher Edition, pages 41, 55, and 69) include a color-coded description of the task that corresponds to targeted elements in each dimension, although the specific targeted elements are not identified. The guides also describe four levels of proficiency for each of the attributes. The scoring guides do not provide example student responses for each level of proficiency. Note that it would be possible for students to score "met" on the CCC-related row without showing any evidence of understanding the CCC. For example, on pages 41 and 69, students could represent the atmosphere, water, lake bottom, producers, and consumers, and including more components doesn't necessarily indicate that students better understand the CCC. In the modeling scoring guidance in Investigation 2 (Teacher Edition, page 55), the rubric does not include indicators to provide evidence that students understand the high school-level CCC elements as general concepts (e.g., that people should always look for boundaries and initial conditions when analyzing systems, or that models can be used to simulate systems). Scoring guidance does not distinguish the high school element from this middle school element: *Models can be used to represent systems and their interactions — such as inputs, processes, and outputs — and energy, matter, and information flows within systems.*
- Scoring guidelines are provided for the explanations that students write after each investigation. For example:

  - Each formative assessment scoring guide includes the following categories: Evidence of Proficiency, Descriptors of Grade-Level-Appropriate Responses, and Differentiation Strategies. These categories help the teacher see a range of student understanding and what a proficient student response looks like.
  - The scoring guides do not break apart student answers such that the teacher could see what components would be necessary for students to show proficiency for each dimension, and thus they mainly provide guidance for interpreting DCI understanding.
  - The scoring guides do not specify which of the targeted elements of each the three dimensions are being assessed or scored in each assessment, although three-dimensional assessment targets are provided. For example: "Revise your model of the lake ecosystem to include additional boundaries, inputs, outputs, and interactions and use it to illustrate how changes in components caused changes in matter cycling and energy transfer that caused the system to become unbalanced and led to the fish kill" (Teacher Edition, page 55).
  - Launching the Phenomenon section: Suggested student answers are given for students' initial explanations of the phenomenon (Teacher Edition, page 25). Some criteria are given for the source of evidence, but no criteria are given for the reasoning section. This is a missed opportunity to support teachers in doing a pre-assessment on students' reasoning abilities.
- Formative Assessment and Differentiation Guides for the Performance Tasks throughout the lesson include a "Descriptors of Grade-Level-Appropriate Responses" column and a "Differentiation Strategies" column that provide the teacher with support in what to look for in student responses and how to adapt instruction depending on whether the students are above or below the expected level of proficiency. These scoring guides provide explicit guidance for the teacher for informing instruction based on student responses. Some examples include:
  - Investigation 1: Scoring guidance is related to the DCI content of students' explanations at the end of the investigation (Teacher Edition, page 43). Leveled descriptors are not included related to CCCs or SEPs.
  - Investigation 2: Scoring guidance is related to the DCI content of students' explanations at the end of the investigation (Teacher Edition, page 57). Some difference in student performance of all three dimensions can be seen between the full and partial understanding descriptors, but guidance is not provided to help teachers distinguish between students who understand the DCI but not the CCC or the SEP.
  - Investigation 3: Scoring guidance is related to the DCI content of students' explanations at the end of the investigation (Teacher Edition, page 71). Some indicators of student performance in all three dimensions can be seen in the full understanding descriptor, but the partial and limited understanding descriptors only include reduced DCI understanding. The remediation strategies section seems to indicate that students should be showing proficiency in one or more **Cause and Effect** CCC elements, but no **Cause and Effect** elements are targeted in the lesson.

***Suggestions for Improvement***

- Identifying the assessment targets for each scoring guide (at the element level for each of the three dimensions) could help clarify what specific elements are being assessed in the performance tasks.
- Including scoring guidance specifically for each dimension and identifying (e.g., through color coding student answers or breaking apart student answers into components) which dimension and element the scoring guidance for the performance tasks aligns with could help increase the rating for this criterion. For example, the guidance on page 43 could indicate which part of the "full understanding" student responses indicate CCC understanding, or separate descriptors could be written for each dimension. Critical Feature 3.3 in the Critical Features of Instructional Design for Today's Science Standards document shows an example.

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

The reviewers found extensive evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples because the lesson assessments use grade-appropriate vocabulary and the assessment scenarios are not biased. Students have opportunities to complete tasks through developing models, writing, and creating posters. Students have a few opportunities to choose the modality of their responses, and most tasks are communicated to students through both text and verbal directions.

Related evidence includes:

- The student readings are accompanied by images and graphics (Student Guide, pages S–30 to S–36).
- Some of the tasks in the Student Guide are communicated to students only through text. For example, in Investigation 1, the teacher is told "Use sustained silent writing to have individual students complete the Explain questions in the Student Guide. Question 1 provides a writing scaffold for Claim–Evidence–Reasoning work" (Teacher Edition, page 30). The teacher is not prompted to talk through the task with students.

- Many different modalities are used throughout the lesson for students to show their understanding, such as writing, talking, graphing, and drawing. However, most of the time students do not have a choice in the modality to use.
    - Lesson Introduction: "To address the needs of all learners, students are encouraged to make their thinking visible in multiple ways. As they develop and revise their model of a freshwater lake ecosystem, they are encouraged to use sketches to show components and arrows to illustrate relationships between components. Provide resources for students to incorporate photos and images to represent components in a way that will help them make connections between the role of components and how they interact with other components" (Teacher Edition, page 17).
    - Investigation 1: In the directions for student models, the teacher is told "Consider providing chart paper and markers to provide opportunities for all learners to make their thinking visible in multiple ways" (Teacher Edition, page 32). Note, however, that all students are also required to show understanding through writing, meaning they don't have a choice about the writing. For example: "Have students complete the writing scaffold for Investigation 1 Performance Task individually" (Teacher Edition, page 32).
    - Investigation 3: "Have each lab group prepare a research poster to share the design and results of their investigation. Provide them with markers, chart paper or poster boards, and other materials that may be useful such as tape, scissors, and glue. As a digital alternative, consider having students prepare a presentation slide, including photos or videos they may have taken during the investigation. If they choose this option, allow them to use a device such as a laptop to display their presentation" (Teacher Edition, page 63).
    - In the Final Performance Task, students are asked to respond by writing and developing a model (Student Guide, pages S–27 and S–28).

***Suggestions for Improvement***

- Consider ensuring that the information and directions in all tasks are conveyed through more than one modality (e.g., text plus other methods such as graphs, images, discussion, etc.).
- Consider providing students a choice of modality of response in additional tasks.

| OVERALL CATEGORY III SCORE:<br>**3**<br>(0, 1, 2, 3) | |
|---|---|
| **Lesson Scoring Guide – Category III** | |
| **Criteria A–D** | |
| **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 three criteria, including A |
| **1** | Adequate evidence for at least two criteria in the category |
| **0** | Adequate evidence for no more than one criterion in the category |

# SCORING GUIDES

## SCORING GUIDES FOR EACH CATEGORY

### LESSON SCORING GUIDE – CATEGORY I (CRITERIA A–C)

### LESSON SCORING GUIDE – CATEGORY II (CRITERIA A–E)

### LESSON SCORING GUIDE – CATEGORY III (CRITERIA A–D)

## OVERALL SCORING GUIDE

# Scoring Guides for Each Category

| Lesson Scoring Guide – Category I (Criteria A–C) | |
|---|---|
| **3** | Extensive evidence to meet at least two criteria and at least adequate evidence for the third. |
| **2** | Adequate evidence to meet all three criteria in the category. |
| **1** | Adequate evidence to meet at least one criterion in the category but insufficient evidence for at least one other criterion. |
| **0** | Inadequate (or no) evidence to meet any criteria in the category. |

| Lesson Scoring Guide – Category II (Criteria A–E) | |
|---|---|
| **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 four criteria, including A |
| **1** | Adequate evidence for at least two criteria in the category |
| **0** | Adequate evidence for no more than one criterion in the category |

| Lesson Scoring Guide – Category III (Criteria A–D) | |
|---|---|
| **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 three criteria, including A |
| **1** | Adequate evidence for at least two criteria in the category |
| **0** | Adequate evidence for no more than one criterion 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) |