5th

8th

11th

M-Step™

Michigan Student Test of Educational Progress

2018 Science Grades 5, 8, and 11 Annotated Sample Items

PRACTICES

CORE IDEAS

CROSSCUTTING

MICHIGAN Department of Education

Contents

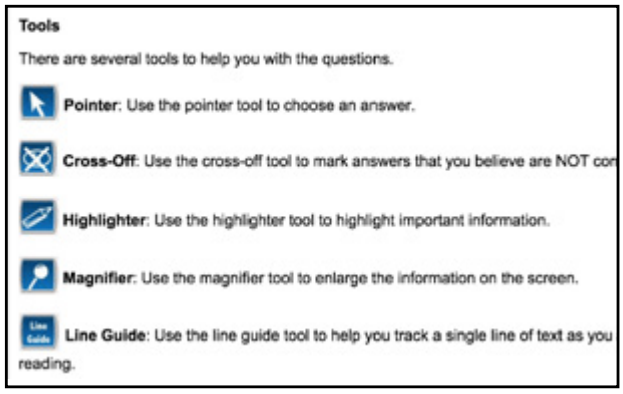
Purpose

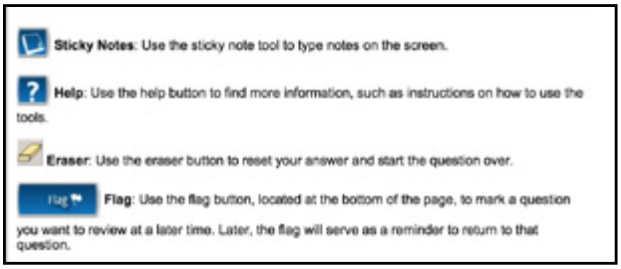
The purpose of the M-STEP Science Assessment Annotated Sample Item Set is to introduce students, teachers, and test administrators to the new item cluster format, item types, and to illustrate alignment. This is not a comprehensive sample test and does not represent all the standards that will be assessed on the Science M-STEP. Additionally, the examples within this document have been taken from the ***Online Tools Tutorial (OTT)***, which is openly available to the public.

The OTTs can be accessed by using the Chrome browser and going to https://wbte.drcedirect.com/MI/portals/mi/. From there, select the "Online Tools Training" underneath MSTEP. The science sample item sets can be found in Grades 5, 8, and 11. The username and password information are given on the login screen.

The test directions presented there explain all the tools and functionality of the online platform. Therefore, you may see icons like those pictured below in this document. However, these tools only relate to online functionality, and their use is not fully discussed in this document.

Online Testing Tools:





This M-STEP Science Assessment Annotated Sample Item Set offers details about the item clusters, student response types, correct responses, and related scoring considerations for the included sample item set. These items have been selected to show some of the new approaches being used to measure the Michigan K-12 Science Standards (MSS) adopted in 2015. The sample item set is fully representative of all current item types included in the field test, and additional samples will be provided over time. The sample item set covers one item cluster and one mini item cluster in grade 5, one item cluster in grade 8, and one item cluster in grade 11. The various item types are not limited to a particular grade level and could appear for any grade.

These item clusters were created during the first round of development. Some people may find aspects that could be improved. The process for item development and vetting is working to ensure that these new types of 2 and 3 dimensional items represent best knowledge and practice possible for large-scale state assessments.

Within this guide, the following terms will be used:

- **Grade Level:** The intended grade level in which the item or item cluster is presented to the student
- **Topic Bundle:** The group of performance expectations (Michigan K-12 Science Standards) that are assessed using the item cluster
- **Science and Engineering Practices (SEP):** Descriptions of behaviors that scientists and engineers engage in as they investigate the natural world and design solutions
- **Disciplinary Core Ideas (DCI):** Most essential ideas in the major science disciplines that all students should understand during their K-12 education

- **Crosscutting Concepts (CCC):** Interdisciplinary skills that unify the study of science and engineering through their common application across fields
- **Dimensions:** The elements that make up the Performance Expectations or standards; each standard has three dimensions including SEP, DCI, and CCC
- **Item Cluster:** A stimulus and a group of 5-8 items designed to assess students integrated science knowledge, skills, and abilities about an entire topic bundle; some stimuli are presented in more than one part throughout cluster
- **Mini Item Cluster:** A stimulus and a group of 2-6 items designed to assess students integrated science knowledge, skills, and abilities about a portion of a topic bundle
- **Stimulus:** A passage with or without pictures, tables, graphs, etc., used to present the phenomenon to the students; stimuli can be one or more than one part
- **Key:** The expected student response or example response from a score point value
- **CR Rubric and Sample Student Responses:** Score point representations for each score point for constructed response items
- **Assessment Claim:** A short description of how students need to integrate their knowledge, skills, and abilities in order to answer the question (e.g., the knowledge-in-use)
- **Hand Scoring** and **Automated Scoring:** Constructed response items are hand-scored meaning the items are scored by human scorers based on the rubric; technology-enhanced items and multiple-choice items are scored by a machine (Automated Scoring)

Each item is aligned to at least two dimensions (DCI+CCC, SEP+ DCI, SEP+CCC) and some are aligned to three dimensions (DCI+SEP+CCC). The items may have differing degrees of alignment. The sample item set represents some, but not all, possible degrees of alignment to the three dimensions.

Science and Engineering Practices Reference Table

1	Asking Questions and Defining Problems
2	Developing and Using Models
3	Planning and Carrying out Investigations
4	Analyzing and Interpreting Data
5	Using Mathematics and Computational Thinking
6	Constructing Explanations and Designing Solutions
7	Engaging in Argument from Evidence
8	Obtaining, Evaluating, and Communicating Information

For more information on the Science and Engineering Practices, see Appendix F of the NGSS (https://www.nextgenscience.org/sites/default/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf).

Crosscutting Concepts Reference Table

1	Patterns
2	Cause and Effect
3	Scale, Proportion, and Quantity
4	Systems and System Models
5	Energy and Matter
6	Structure and Function
7	Stability and Change

For more information on the Crosscutting Concepts, see Appendix G of the NGSS (https://www.nextgenscience.org/sites/default/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf).

Disciplinary Core Ideas Reference Table

Physical Sciences	
PS1	Matter and its interactions
PS2	Motion and stability: Forces and interactions
PS3	Energy
PS4	Waves and their applications in technologies for information transfer
Life Sciences	
LS1	From molecules to organisms: Structures and processes
LS2	Ecosystems: Interactions and variation of traits
LS3	Heredity: Inheritance and variation of traits
LS4	Biological evolution: Unity and diversity
Earth and Space Sciences	
ESS1	Earth's place in the universe
ESS2	Earth's systems
ESS3	Earth and human activity
Engineering, Technology, and Applications of Science	
ETS1	Engineering design
ETS2	Links among engineering, technology, science, and society

For more information on the Disciplinary Core Ideas, see the Framework (https://www.nap.edu/read/13165/chapter/2#3) **or** Appendix E of the NGSS (https://www.nextgenscience.org/sites/default/files/resource/files/AppendixE-ProgressionswithinNGSS-061617.pdf).

Key Example 1

Part	Key	Scoring
A: drop-down 1	occurred	*
A: drop-down 2	did	*
B	a	1

Assessment Claim: The students use the data table to determine if a chemical reaction occurred and provide the characteristics of iron that indicate a chemical reaction occurred as evidence.

Some questions may have more than one part. All parts of the question must be answered correctly to gain one point.

Asterisks indicate that all parts of the question must be answered correctly to receive one point.

Key Example 2

Part	Key	Scoring
A: Initial Iron Atoms (see model on previous page)	4 iron (Fe) atoms	*
A: Oxygen in the Air (see model on previous page)	6 oxygen (O) atoms	1
B	The model can explain a change in color because the model shows atoms recombining to form a new substance. Color change can happen when a new substance is formed.	1
C	One limitation of using this model is (answers may vary but could include: the colors of the atoms don't show the color turning to red; the oxygen atoms are in pairs before the reaction occurs; etc.)	1
Assessment Claim: The students complete a model to show conservation of matter during a chemical reaction. Students then explain how the model shows a property change and the limitations of the model.		

Constructed response items are hand scored by Michigan educators. The scoring rubrics and process take a holistic approach to scoring the items.

The model must be constructed correctly to earn one point. The entire item is worth three points.

Metadata Explanation

Phenomenon: A description of the phenomenon or problem presented in the item cluster.								
Stimulus or Item Part	Brief Description	Item Type	DCI	SEP	CCC	Points	Estimated Time (min)	Hand or Automated Scoring
Stimulus Part 1	Stimulus Description	n/a	n/a	n/a	n/a	n/a	#	
1	Item Part Description	MC / CR / TE	PS4.B	n/a	2	1	#	A
2a & 2b	Item Part Description & Item Part Description	MC / CR / TE & MC / CR / TE	LS1.D	7	2	1	#	A
		Total	**#/#**	**#/#**	**#/#**	**#**	**#**	

Indicates a multiple part item. All parts of the multipart items assess the dimensions shown.

Totals in the DCI, SEP and CCC column refer to the number of elements assessed by the item cluster versus the number of elements in the topic bundle.

Shows the DCI assessed in the item. To look up the code go to the Framework (https://www.nap.edu/read/13165/chapter/1). The specific DCI elements are not specified in this document.

Shows the SEP assessed in the item. To look up the code, see page 5.

Shows the CCC assessed in the item. To look up the code, see page 5.

Grade 5 SAMPLE ITEM CLUSTER: Lights Out!
Topic Bundle: Structure, Function and Information Processing Standards*

4.Structure, Function, and Information Processing

4.Structure, Function, and Information Processing

Students who demonstrate understanding can:

4-PS4-2. **Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.** [Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.]

4-LS1-1. **Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.** [Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin.] [Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.]

4-LS1-2. **Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.** [Clarification Statement: Emphasis is on systems of information transfer.] [Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop a model to describe phenomena. (4-PS4-2) • Use a model to test interactions concerning the functioning of a natural system. (4-LS1-2) **Engaging in Argument from Evidence** Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Construct an argument with evidence, data, and/or a model. (4-LS1-1)	**PS4.B: Electromagnetic Radiation** • An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2) **LS1.A: Structure and Function** • Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1) **LS1.D: Information Processing** • Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (4-LS1-2)	**Cause and Effect** • Cause and effect relationships are routinely identified. (4-PS4-2) **Systems and System Models** • A system can be described in terms of its components and their interactions. (4-LS1-1), (LS1-2)

Item alignment for SEPs and CCCs does **not** require that the item aligns directly with the element (bullet) displayed in the foundation boxes but can align with **any** appropriate element listed as part of the SEP or CCC in Appendices F and G of the Next Generation Science Standards.

Item alignment for DCIs requires that the item aligns directly with the element (bullet) displayed in the foundation boxes.

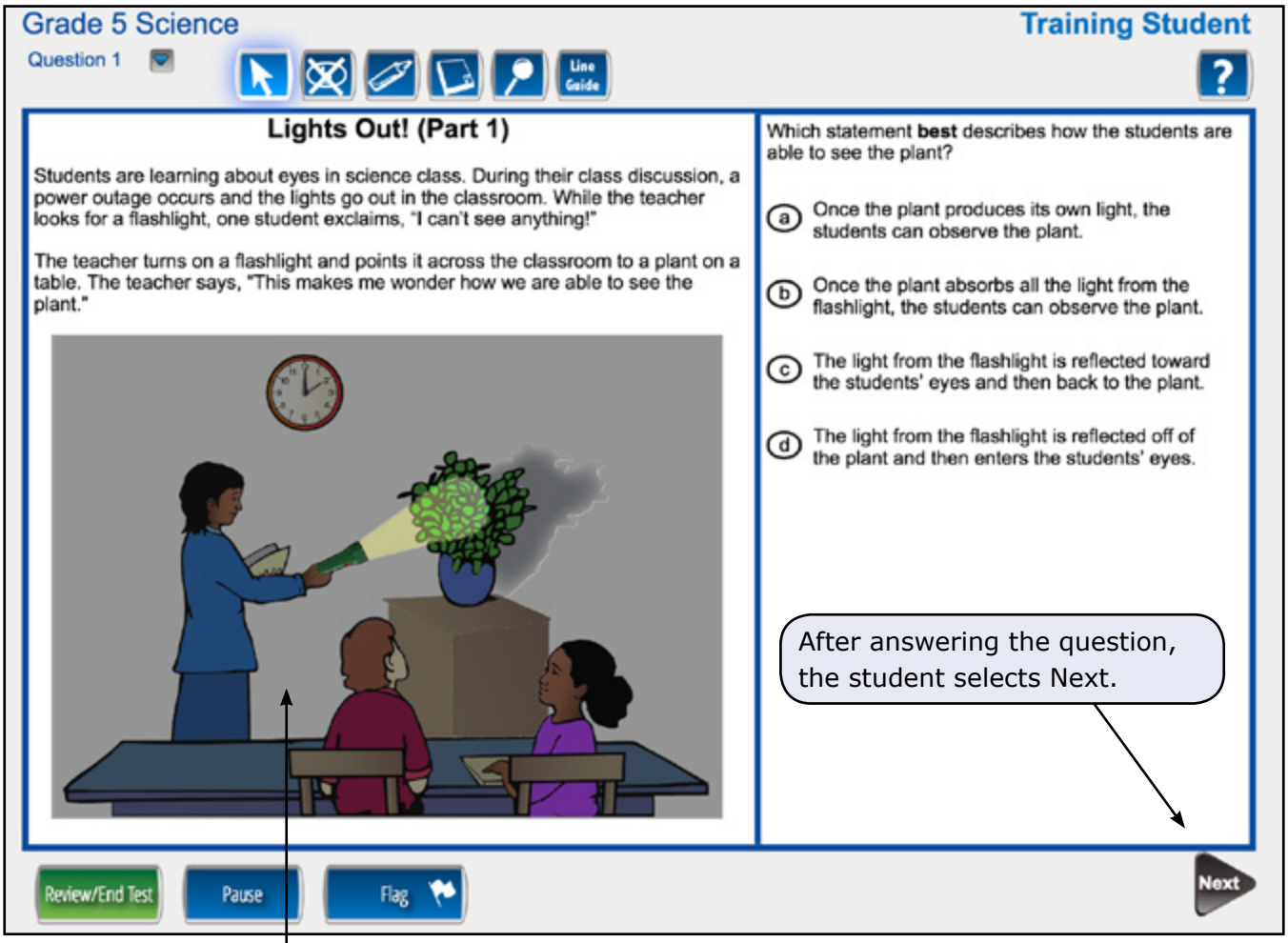
*Document link: https://www.nextgenscience.org/topic-arrangement/4structure-function-and-information-processing

Grade 5 Sample Item Cluster: Lights Out!, Metadata Table

Phenomenon: Human's ability to see in varying levels of light								
Stimulus or Item Part	Brief Description	Item Type	DCI	SEP	CCC	Points	Estimated Time (min)	Hand or Automated Scoring
Stimulus Part 1	The lights go out in a classroom	n/a	n/a	n/a	n/a	n/a	1	n/a
1	Explain ability to see	Multiple Choice	PS4.B	n/a	2	1	1	A
2	Explain how eyes process light	Multiple Choice	LS1.D	n/a	2	1	1	A
3	Complete path of light model	Drag and Drop	PS4.B & LS1.D	2	4	1	2	A
Stimulus Part 2	Eyes as specialized structures	n/a	n/a	n/a	n/a	n/a	3	n/a
4a & 4b	Predict change based on data & Explain prediction based on data	Multiple Select & Multiple Choice	LS1.A	7	2	1	2	A
5	Explain effect of light on pupils	Drag and Drop	LS1.A	7	2	1	3	A
		Total	**3/3**	**2/2**	**2/2**	**5**	**13**	

The DCI, SEP, and CCC totals refer to the number of the dimensions assessed in the item cluster compared to the number presented in the topic bundle.

Grade 5 Sample Item Cluster: Lights Out!

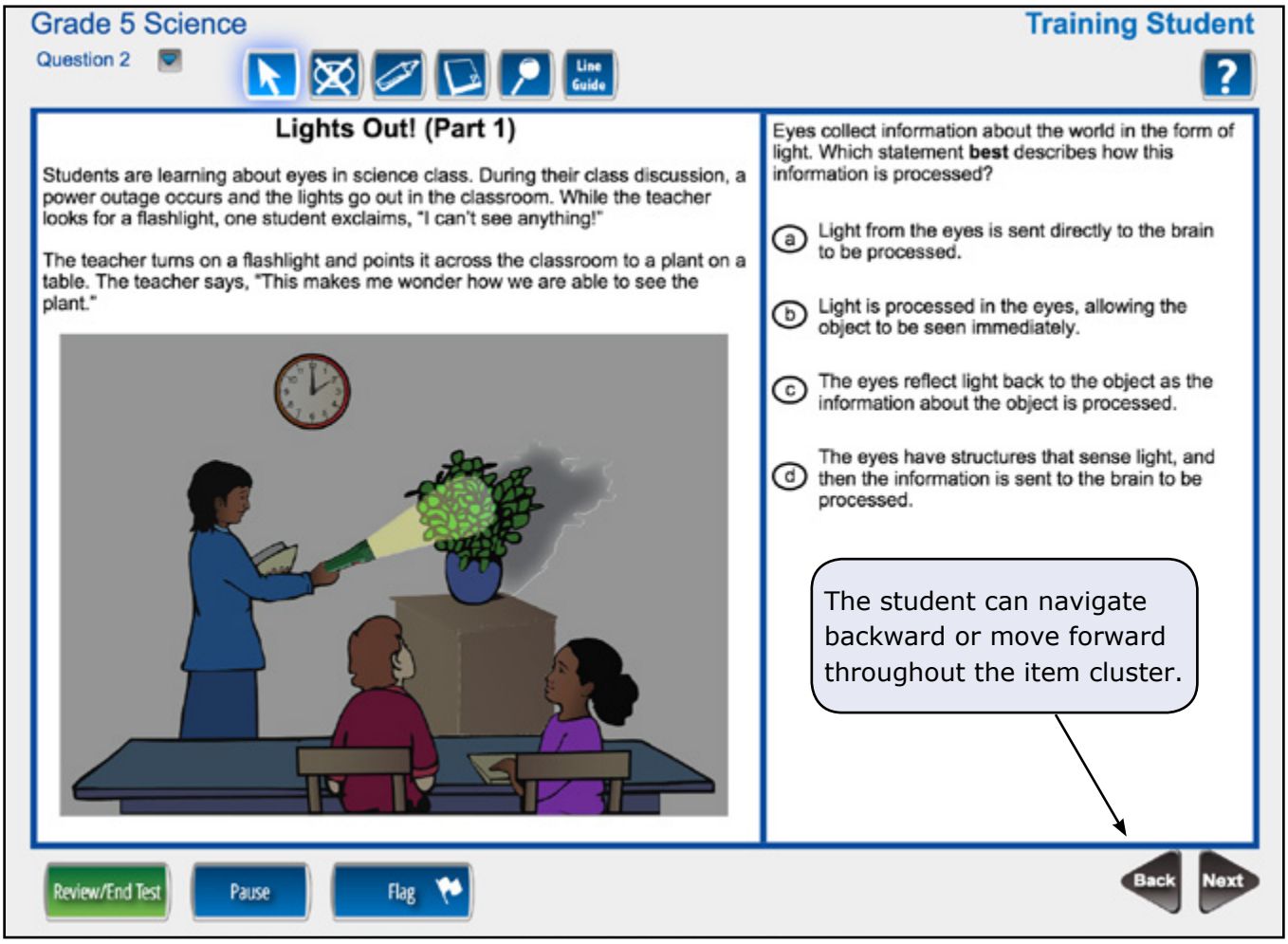


After answering the question, the student selects Next.

Stimulus introduces the phenomenon and remains on the left side of the screen as the items change on the right side of the screen. The student may need to scroll down to read the entire stimulus.

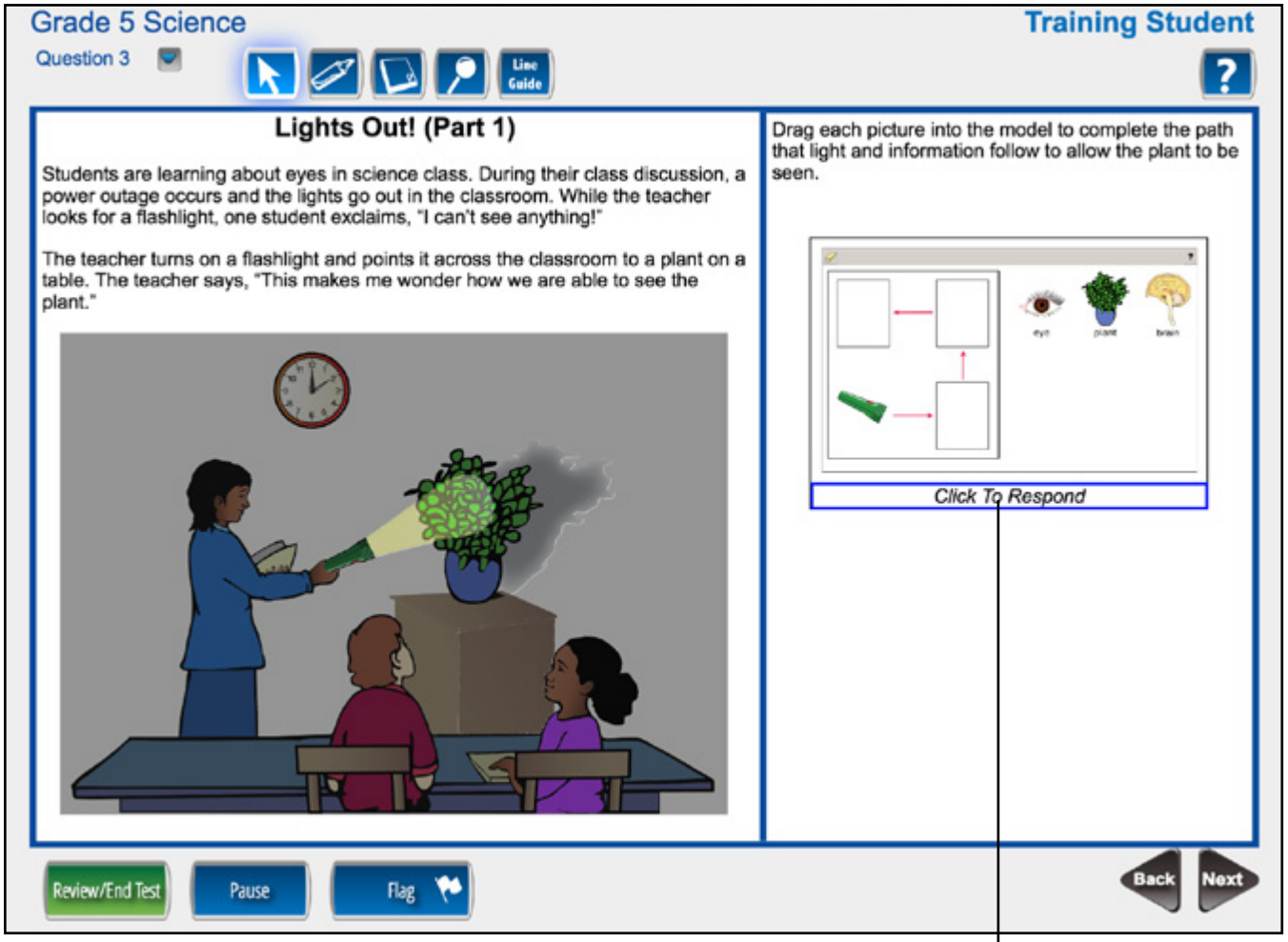
Part	Key	Scoring
NA	d	1
Assessment Claim: The student uses cause and effect rationale to select the correct path of light.		

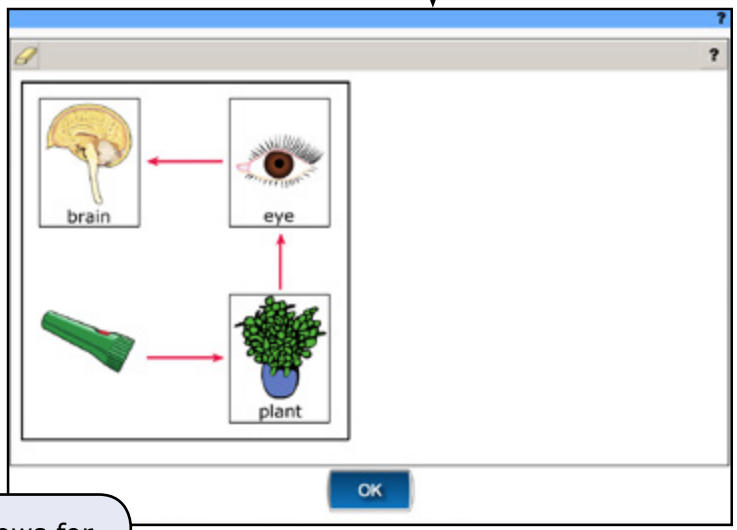
Grade 5 Sample Item Cluster: Lights Out!



Part	Key	Scoring
NA	d	1
Assessment Claim: The student uses cause and effect rationale to select the correct information processing description.		

Grade 5 Sample Item Cluster: Lights Out!

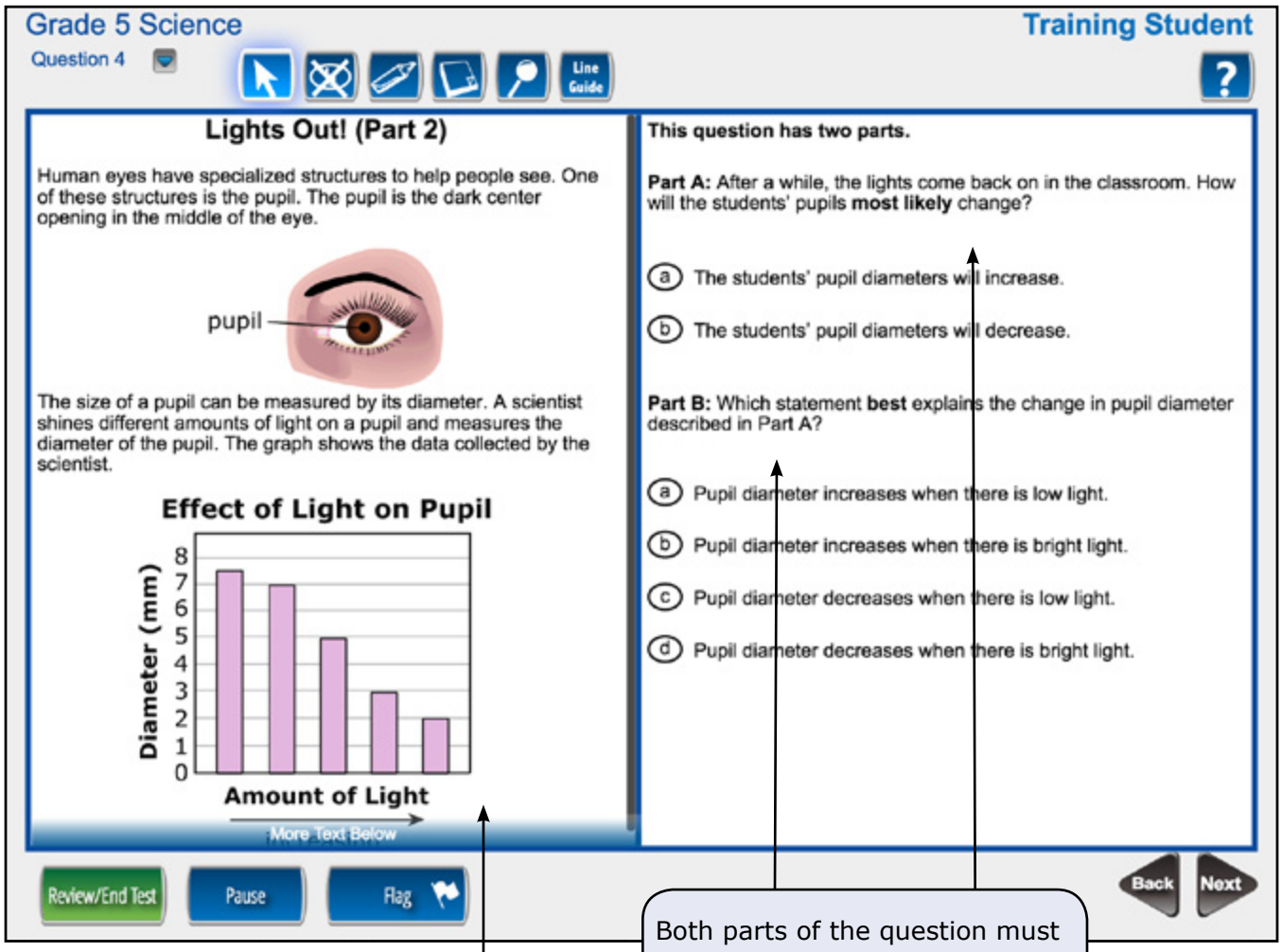




Part (path box)	Key	Scoring
first box	plant	*
next box	eye	*
last box	brain	1
Assessment Claim: The student uses the components of the given system to model the path of light information.		

The "Click to Respond" feature allows for a larger response space in which students can model ideas. The student moves the images on the right into the model to respond to the prompt.

Grade 5 Sample Item Cluster: Lights Out!



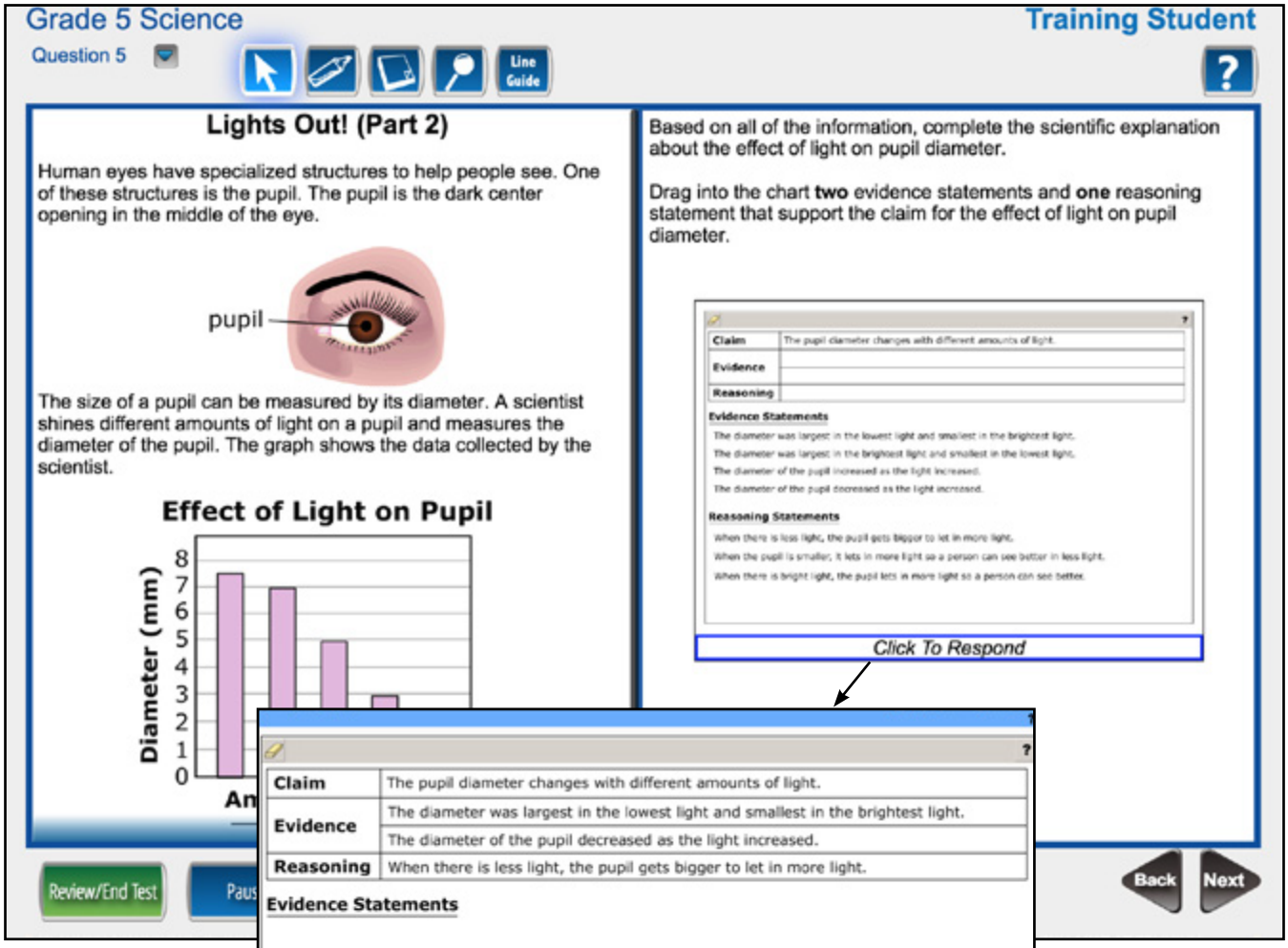
Both parts of the question must be answered correctly for the student to receive 1 point.

The stimulus on the left side of the screen changes to introduce new information regarding the phenomenon. The student can go back to previous stimuli at any time.

Part	Key	Scoring
A	b	*
B	d	1

Assessment Claim: The student chooses a claim portion of an argument regarding effect of light on a pupil and supports the argument using the data given.

Grade 5 Sample Item Cluster: Lights Out!



The student selects and moves sentences from the evidence statements and reasoning statements into the empty table cells to respond to the prompt. **Note:** it is possible to put evidence statements in the reasoning answer area and *vice versa*.

Part	Key	Scoring
Evidence	The diameter was largest in the lowest light and smallest in the brightest light.	*
Evidence	The diameter of the pupil decreased as the light increased.	*
Reasoning	Where there is less light, the pupil gets bigger to let in more light.	1
Assessment Claim: The student builds an argument using the evidence and reasoning provided about how pupils react to different amounts of light.		

Grade 5 SAMPLE MINI ITEM CLUSTER: Grasshoppers
Topic Bundle; Inheritance and Variation of Traits:
Life Cycles and Traits Standards*

3.Inheritance and Variation of Traits: Life Cycles and Traits

3.Inheritance and Variation of Traits: Life Cycles and Traits

Students who demonstrate understanding can:

3-LS1-1. **Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.** [Clarification Statement: Changes organisms go through during their life form a pattern.] [Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction.]

3-LS3-1. **Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.** [Clarification Statement: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.] [Assessment Boundary: Assessment does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples.]

3-LS3-2. **Use evidence to support the explanation that traits can be influenced by the environment.** [Clarification Statement: Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; and, a pet dog that is given too much food and little exercise may become overweight.]

3-LS4-2. **Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.** [Clarification Statement: Examples of cause and effect relationships could be plants that have larger thorns than other plants may be less likely to be eaten by predators; and, animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.
- Develop models to describe phenomena. (3-LS1-1)

Analyzing and Interpreting Data
Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations.
When possible and feasible, digital tools should be used.
- Analyze and interpret data to make sense of phenomena using logical reasoning. (3-LS3-1)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.
- Use evidence (e.g., observations, patterns) to support an explanation. (3-LS3-2)
- Use evidence (e.g., observations, patterns) to construct an explanation. (3-LS4-2)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
- Science findings are based on recognizing patterns. (3-LS1-1)

Disciplinary Core Ideas

LS1.B: Growth and Development of Organisms
- Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (3-LS1-1)

LS3.A: Inheritance of Traits
- Many characteristics of organisms are inherited from their parents. (3-LS3-1)
- Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (3-LS3-2)

LS3.B: Variation of Traits
- Different organisms vary in how they look and function because they have different inherited information. (3-LS3-1)
- The environment also affects the traits that an organism develops. (3-LS3-2)

LS4.B: Natural Selection
- Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. (3-LS4-2)

Crosscutting Concepts

Patterns
- Similarities and differences in patterns can be used to sort and classify natural phenomena. (3-LS3-1)
- Patterns of change can be used to make predictions. (3-LS1-1)

Cause and Effect
- Cause and effect relationships are routinely identified and used to explain change. (3-LS3-2),(3-LS4-2)

Mini item clusters are designed to address particular dimensions within a topic bundle, not the whole topic bundle.

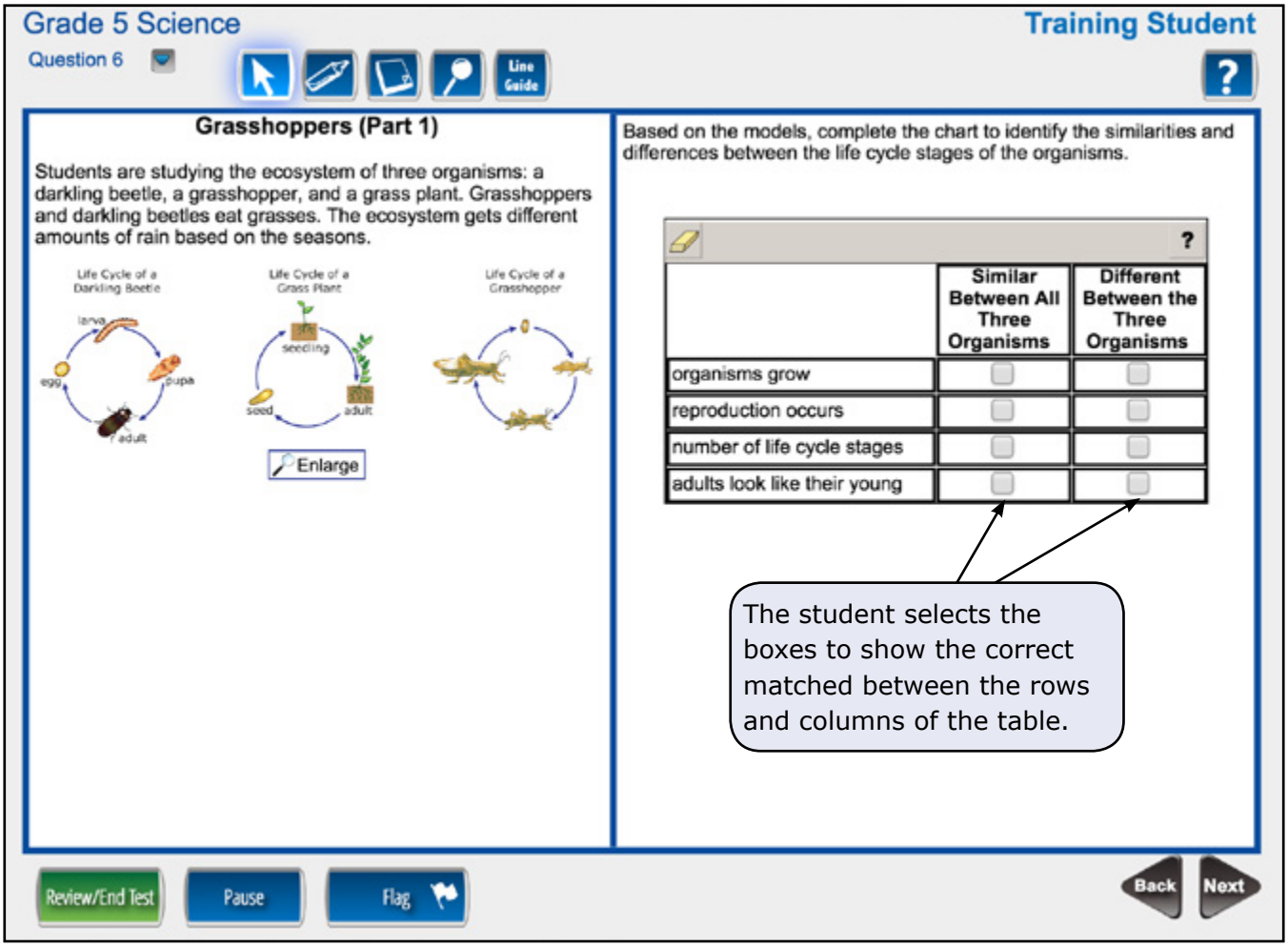
*Document link: https://www.nextgenscience.org/topic-arrangement/3inheritance-and-variation-traits-life-cycles-and-traits

Grade 5 Sample Mini Item Cluster: Grasshoppers, Metadata Table

Phenomenon: Various organisms exist in the same ecosystem but are different								
Stimulus or Item Part	Brief Description	Item Type	DCI	SEP	CCC	Points	Estimated Time (min)	Hand or Automated Scoring
Stimulus Part 1	Several organisms live in the same ecosystem	n/a	n/a	n/a	n/a	n/a	1	n/a
6	Compare life cycles	Matching	LS1.B	2	1	1	1	A
7a & 7b	Predict offspring of parents & Determine similar traits in a species	Multiple Select & Multiple Select	LS3.A	6	1	1	2	A
8	Effect of ecosystem on population	Drag and Drop	LS1.B	2	2	1	2	A
Stimulus Part 2	Environment and grass plants	n/a	n/a	n/a	n/a	n/a	3	n/a
9a & 9b	Determine relevant variable to support claim & Display data to support claim	Hot Text & Graphing	LS3.B	4	2	1	1	A
		Total	**3/6**	**3/3**	**2/2**	**5**	**10**	

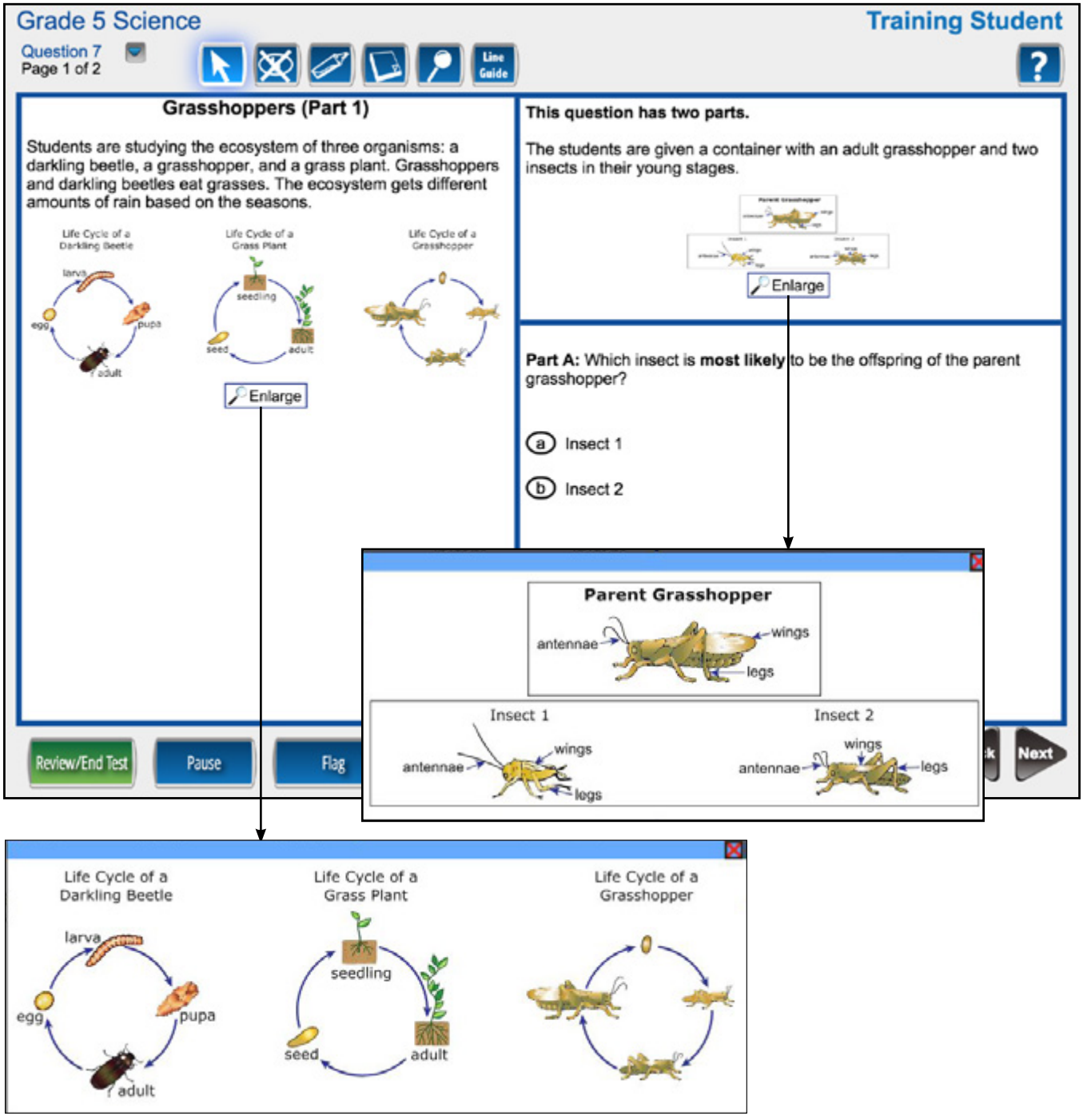
The DCI, SEP, and CCC totals refer to the number of the dimensions assessed in the item cluster compared to the number presented in the topic bundle.

Grade 5 Sample Mini Item Cluster: Grasshoppers



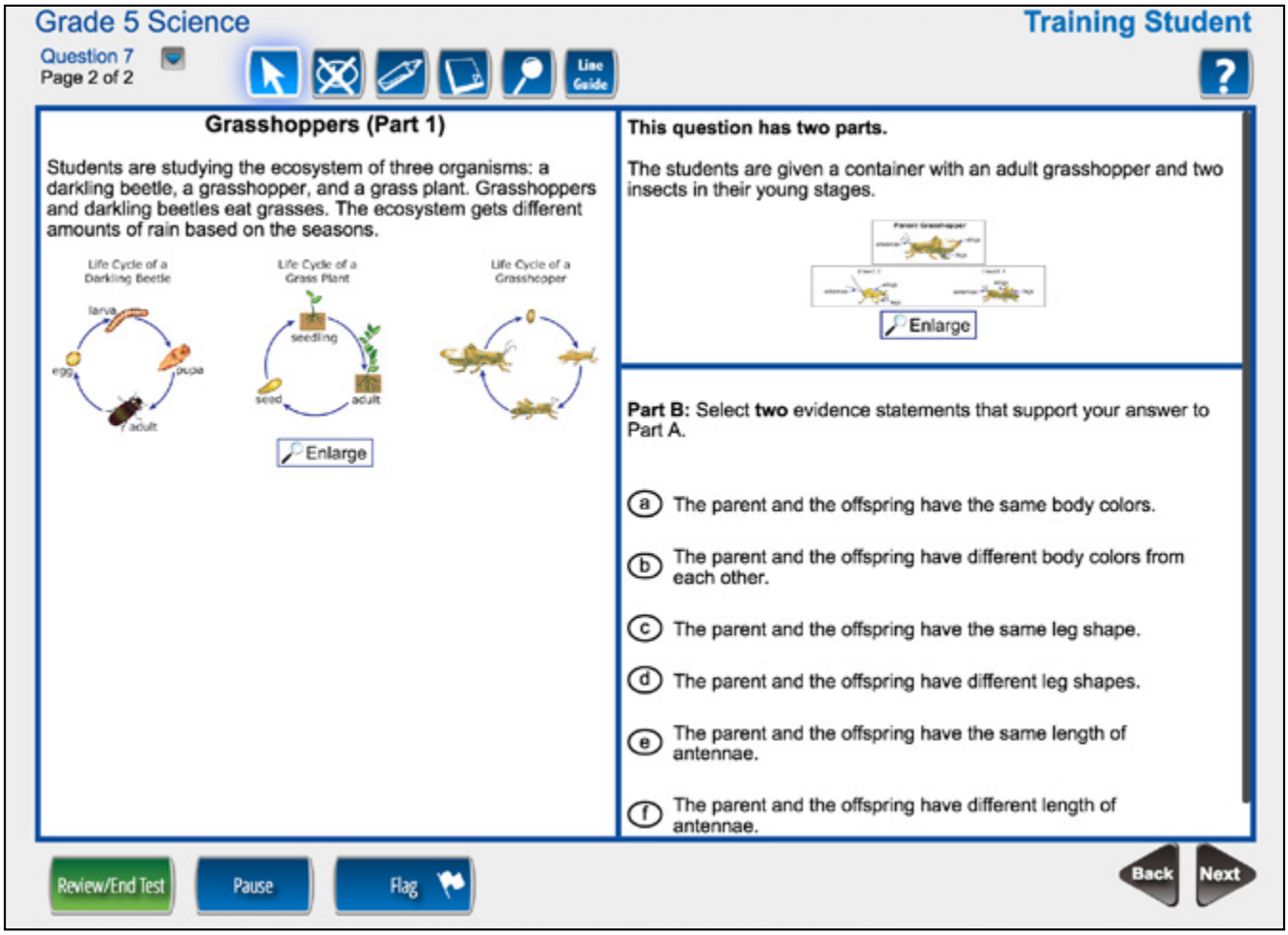
Part	Key	Scoring
organisms grow	Similar	*
reproduction occurs	Similar	*
number of life cycle stages	Different	*
adults look like their young	Different	1
Assessment Claim: The student uses the models to see patterns relating the similarities and differences in organisms' life cycles.		

Grade 5 Sample Mini Item Cluster: Grasshoppers



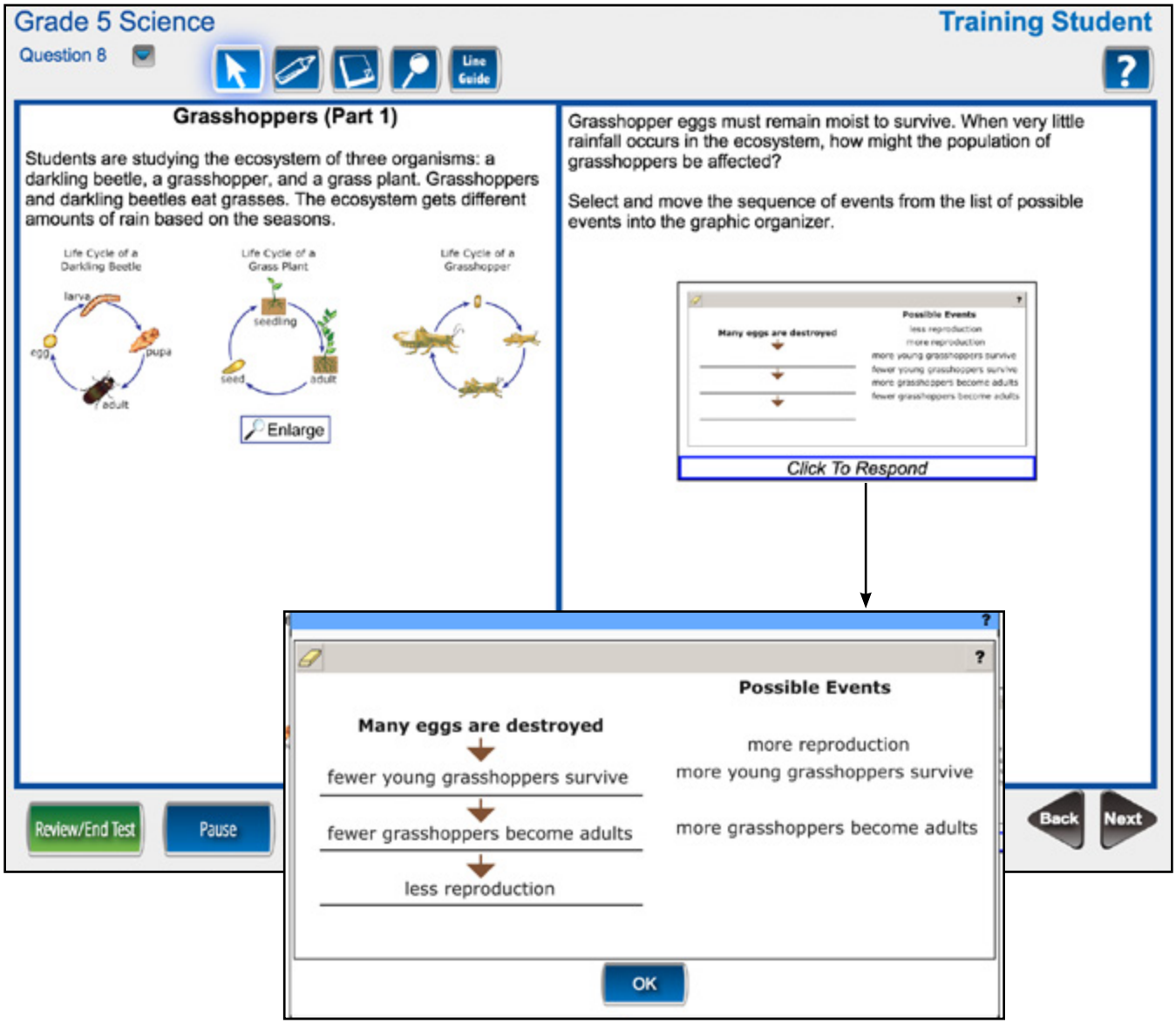
When graphics are enlarged they can overlap. The student can move the enlarged boxes around by selecting and holding on the blue bar at the top and moving the box.

Grade 5 Sample Mini Item Cluster: Grasshoppers



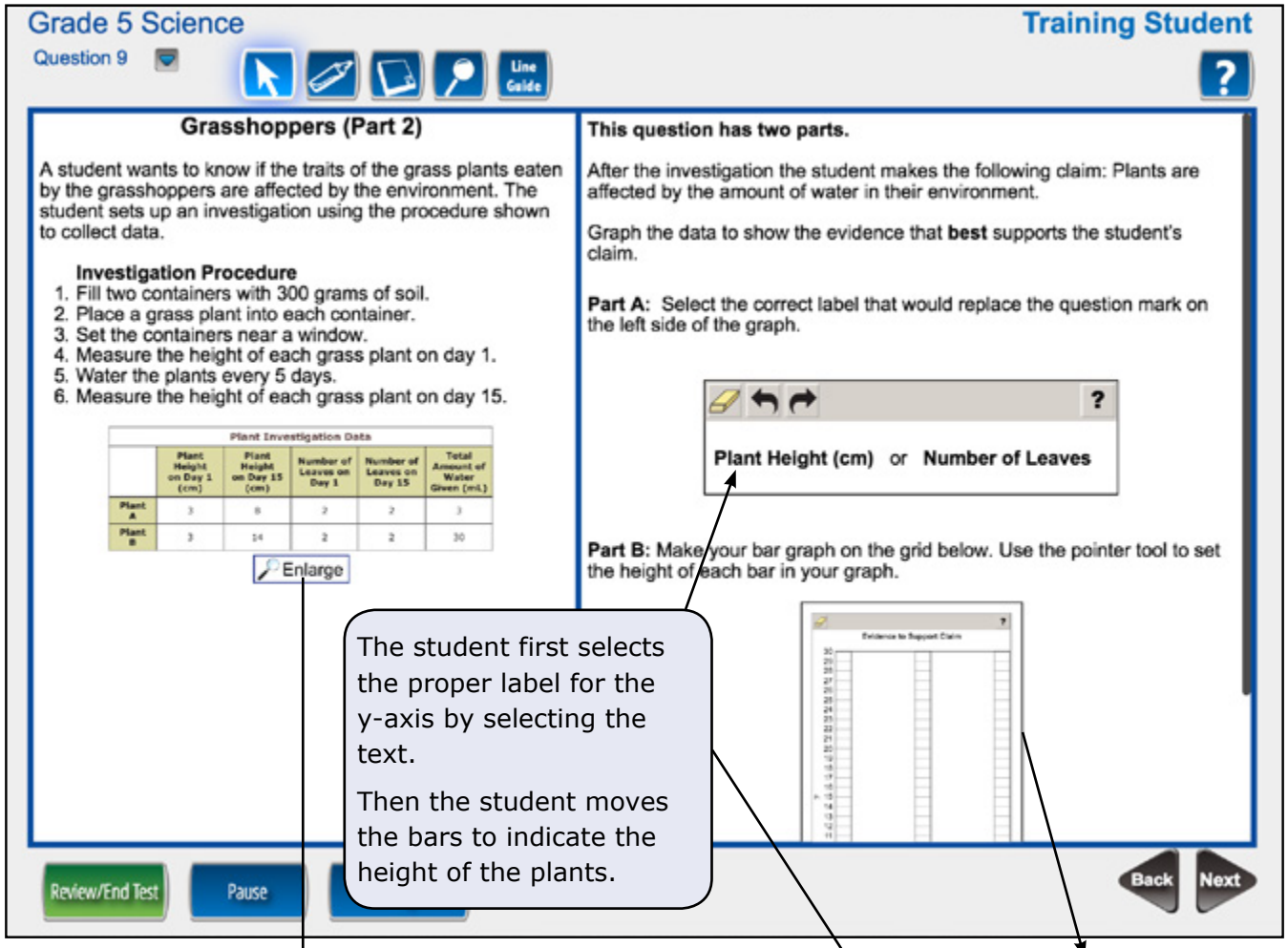
Part	Key	Scoring
A	b	*
B	a and c	1
Assessment Claim: The student claims which offspring is most like a parent and selects two pieces of evidence to support the claim.		

Grade 5 Sample Mini Item Cluster: Grasshoppers



Part (events)	Key	Scoring
first event	fewer young grasshoppers survive	*
next event	fewer grasshoppers become adults	*
last event	less reproduction	1
Assessment Claim: The student models the effect of the amount of rainfall in an environment on the grasshopper population.		

Grade 5 Sample Mini Item Cluster: Grasshoppers

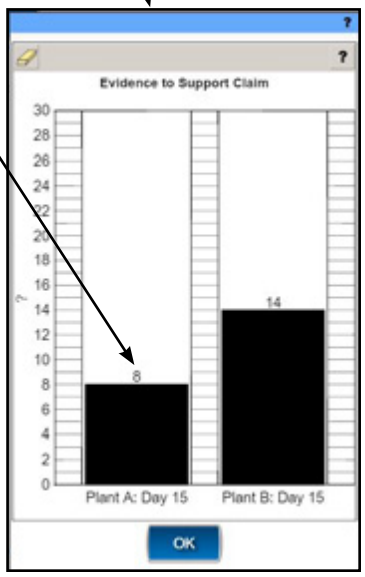


The student first selects the proper label for the y-axis by selecting the text.

Then the student moves the bars to indicate the height of the plants.

Plant Investigation Data

	Plant Height on Day 1 (cm)	Plant Height on Day 15 (cm)	Number of Leaves on Day 1	Number of Leaves on Day 15	Total Amount of Water Given (mL)
Plant A	3	8	2	2	3
Plant B	3	14	2	2	30



Part	Key	Scoring
A	Plant Height (cm)	*
B	8 and 14	1
Assessment Claim: Using the provided data, the student presents the data in graphical form to support the claim that plants are affected by the water in the environment.		

Grade 8 SAMPLE ITEM CLUSTER: Handwarmers
Topic Bundle: Chemical Reactions Standards*

MS.Chemical Reactions

MS.Chemical Reactions

Students who demonstrate understanding can:

MS-PS1-2. **Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.** [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]

MS-PS1-5. **Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.** [Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.] [Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.]

MS-PS1-6. **Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*** [Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.
- Develop a model to describe unobservable mechanisms. (MS-PS1-5)

Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
- Analyze and interpret data to determine similarities and differences in findings. (MS-PS1-2)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.
- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. (MS-PS1-6)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
- Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS1-2)

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
- Laws are regularities or mathematical descriptions of natural phenomena. (MS-PS1-5)

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2) *(Note: This Disciplinary Core Idea is also addressed by MS-PS1-3.)*

PS1.B: Chemical Reactions
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-5) *(Note: This Disciplinary Core Idea is also addressed by MS-PS1-3.)*
- The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS1-5)
- Some chemical reactions release energy, others store energy. (MS-PS1-6)

ETS1.B: Developing Possible Solutions
- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. *(secondary to MS-PS1-6)*

ETS1.C: Optimizing the Design Solution
- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design. *(secondary to MS-PS1-6)*
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. *(secondary to MS-PS1-6)*

Crosscutting Concepts

Patterns
- Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2)

Energy and Matter
- Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5)
- The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6)

Item alignment for DCIs requires that the item aligns directly with the element (bullet) displayed in the foundation boxes.

Item alignment for SEPs and CCCs does **not** require that the item aligns directly with the element (bullet) displayed in the foundation boxes but can align with **any** appropriate element listed as part of the SEP or CCC in Appendices F and G of the Next Generation Science Standards.

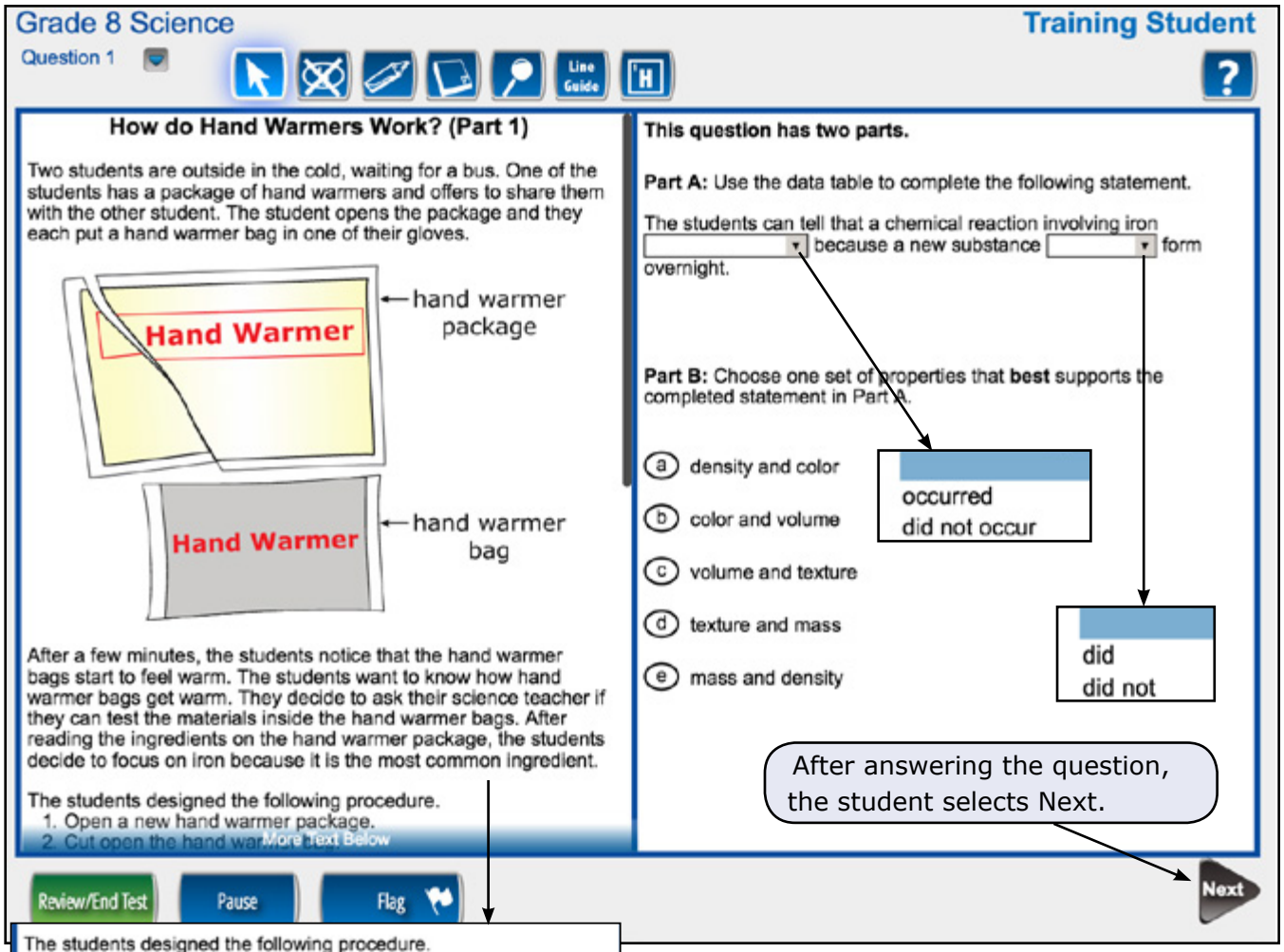
*Document Link: https://www.nextgenscience.org/topic-arrangement/mschemical-reactions

Grade 8 Sample Item Cluster: Handwarmers, Metadata Table

Phenomenon: Handwarmers get warm when you open the package								
Stimulus or Item Part	Brief Description	Item Type	DCI	SEP	CCC	Points	Estimated Time (min)	Hand or Automated Scoring
Stimulus Part 1	Introduction of Handwarmers and initial data	n/a	n/a	n/a	n/a	n/a	1	n/a
1a & 1b	Determine if chemical reaction occurred & Characteristic properties	Drop-Down & Choice	PS1.B & PS1.A	4	1	1	1	A
2	Conservation of mass	Drop-Down	PS1.B	4	5	1	1	A
3a & 3b & 3c	Build a model showing conservation of mass & Explain model & Limitations of model	Drag and Drop & Constructed Response & Constructed Response	PS1.B	2	5	3	4	H
Stimulus Part 2	Handwarmer investigation and data	n/a	n/a	n/a	n/a	n/a	2	n/a
4	Similarities and differences of two systems	Hot Spot	PS1.B	4	1	1	1	A
5	Explain energy transfer in two systems	Drag and Drop	PS1.B	6	5	1	2	A
6	Evaluate a design solution	Multiple Choice	ETS1.B	6	5	1	1	A
7	Determine trade-offs of design solution	Multiple Choice	ETS1.C	6	n/a	1	1	A
		Total	**7/7**	**3/3**	**2/2**	**9**	**15**	

The DCI, SEP, and CCC totals at the bottom of the Metadata table refer to the number of the dimensions assessed in the item cluster compared to the number presented in the topic bundle.

Grade 8 Sample Item Cluster: Handwarmers



The students designed the following procedure.
1. Open a new hand warmer package.
2. Cut open the hand warmer bag.
3. Separate the materials by using a magnet to attract the iron.
4. Place the iron on a dish.
5. Make initial observations and calculations to record properties of the iron.
6. Leave the iron in the dish overnight.
7. Record final observations and calculations the next day.

Iron from Hand Warmer Bag

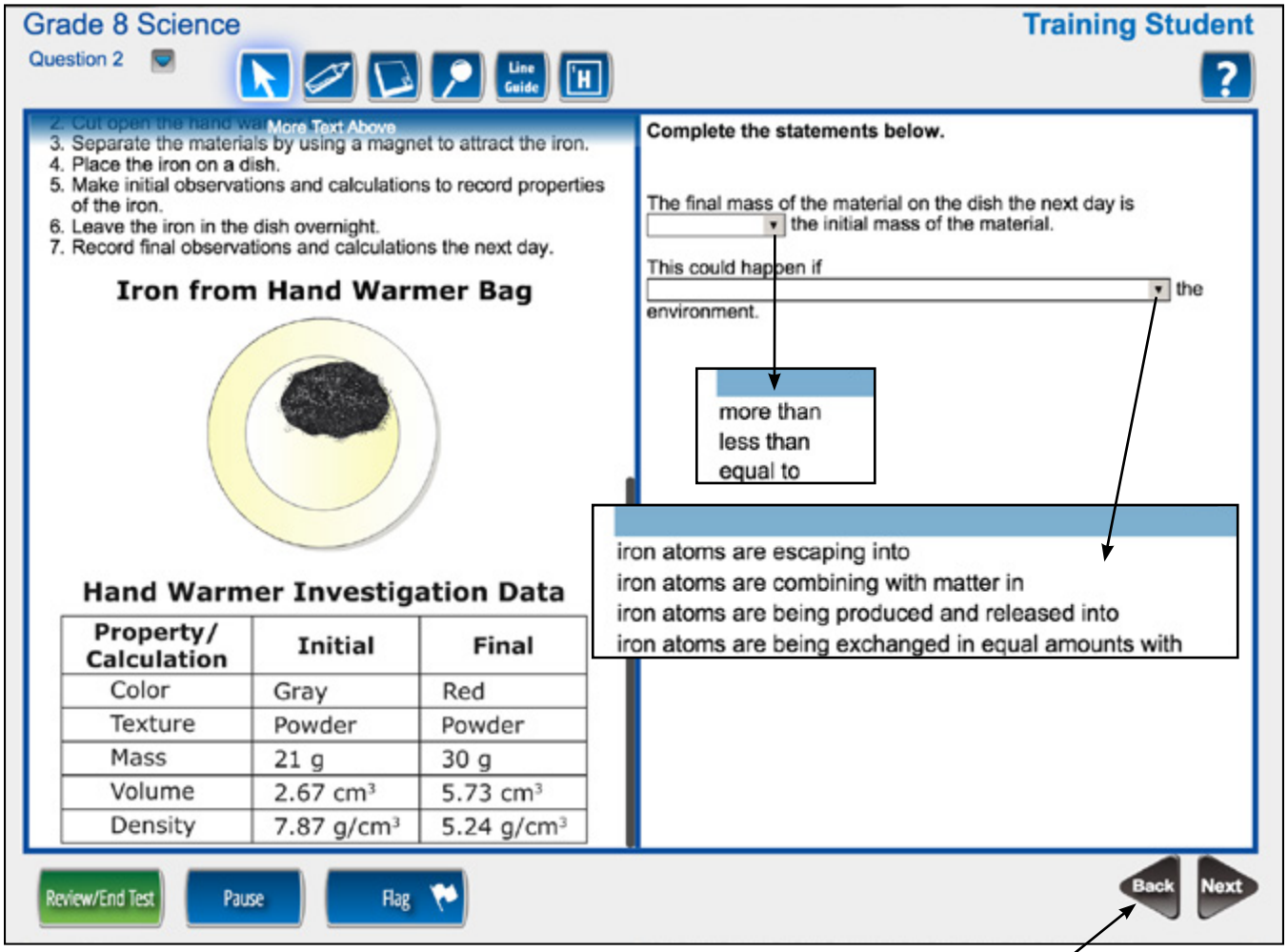
Hand Warmer Investigation Data

Property/ Calculation	Initial	Final
Color	Gray	Red
Texture	Powder	Powder
Mass	21 g	30 g
Volume	2.67 cm^3	5.73 cm^3
Density	7.87 g/cm^3	5.24 g/cm^3

Part	Key	Scoring
A: drop-down 1	occurred	*
A: drop-down 2	did	*
B	a	1
Assessment Claim: The student uses the data table to determine if a chemical reaction occurred and provides the evidence that indicates a chemical reaction occurred.		

Stimulus introduces the phenomenon and remains on the left side of the screen as the items change on the right side of the screen. The student scrolls down to read the entire stimulus.

Grade 8 Sample Item Cluster: Handwarmers

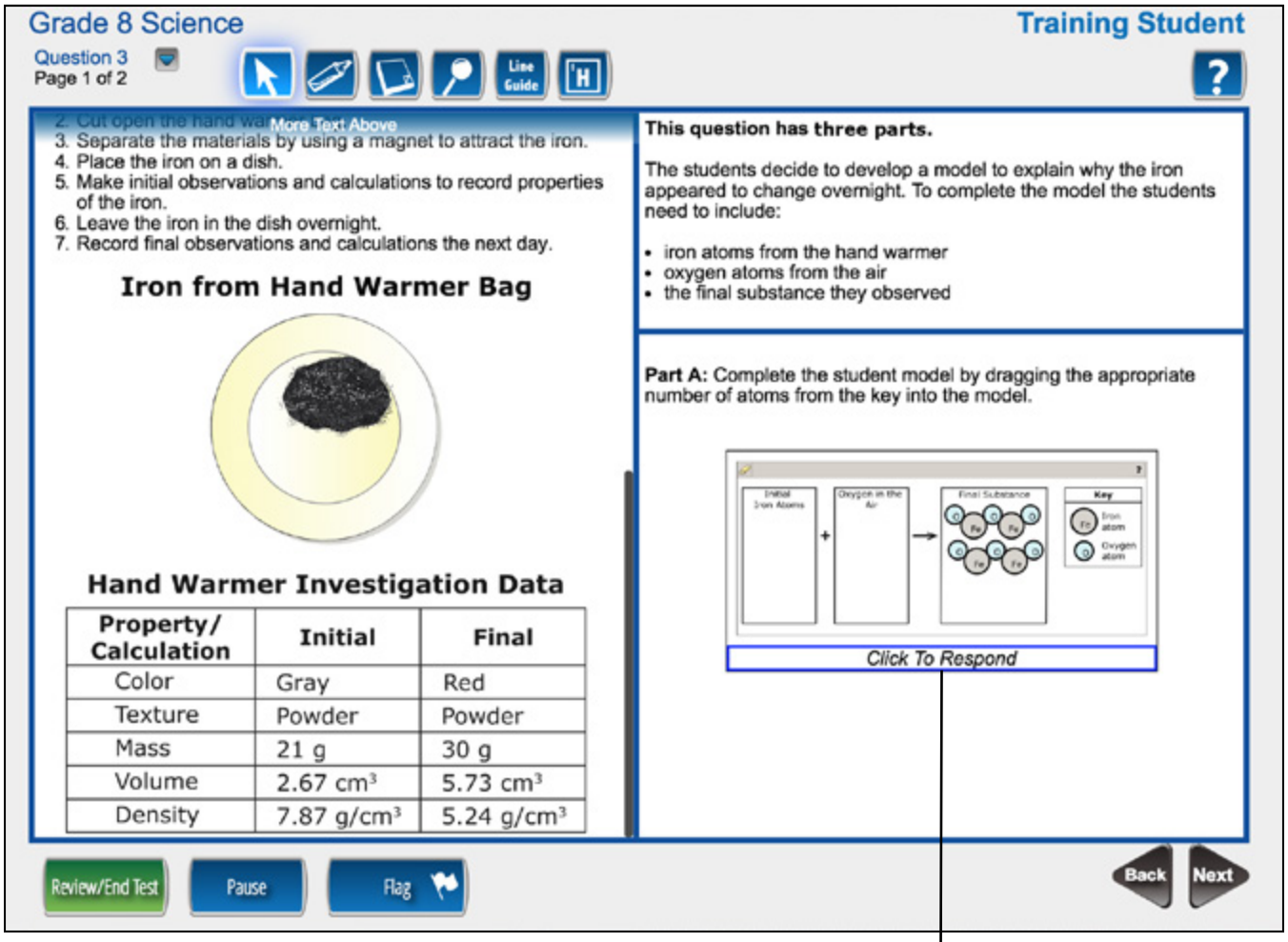


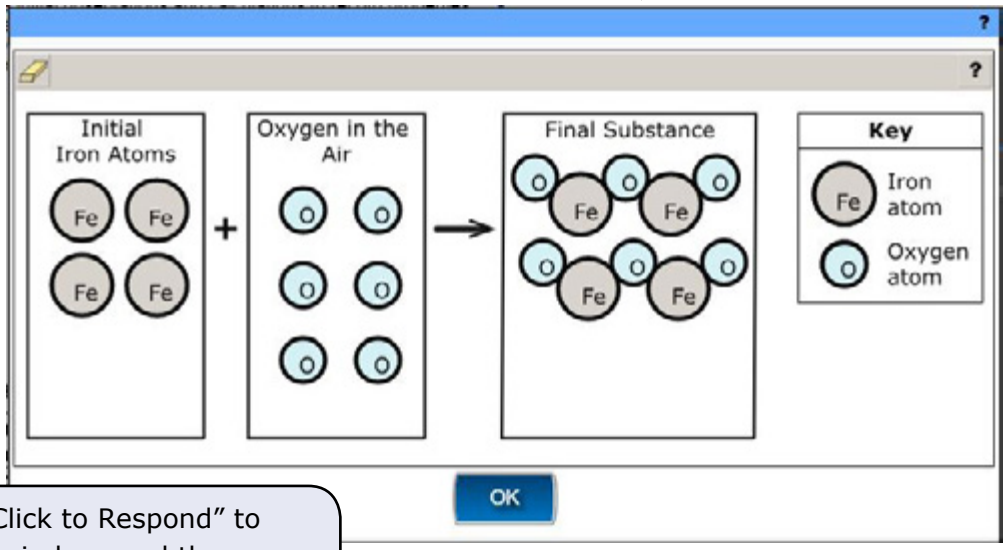
The student can navigate backward or move forward throughout the entire item cluster.

Part	Key	Scoring
drop-down 1	more than	*
drop-down 2	iron atoms are combining with matter in	1

Assessment Claim: The student uses the data table to compare the initial and final mass of the material and then support their answer with reasoning about how the mass of the material increased overnight.

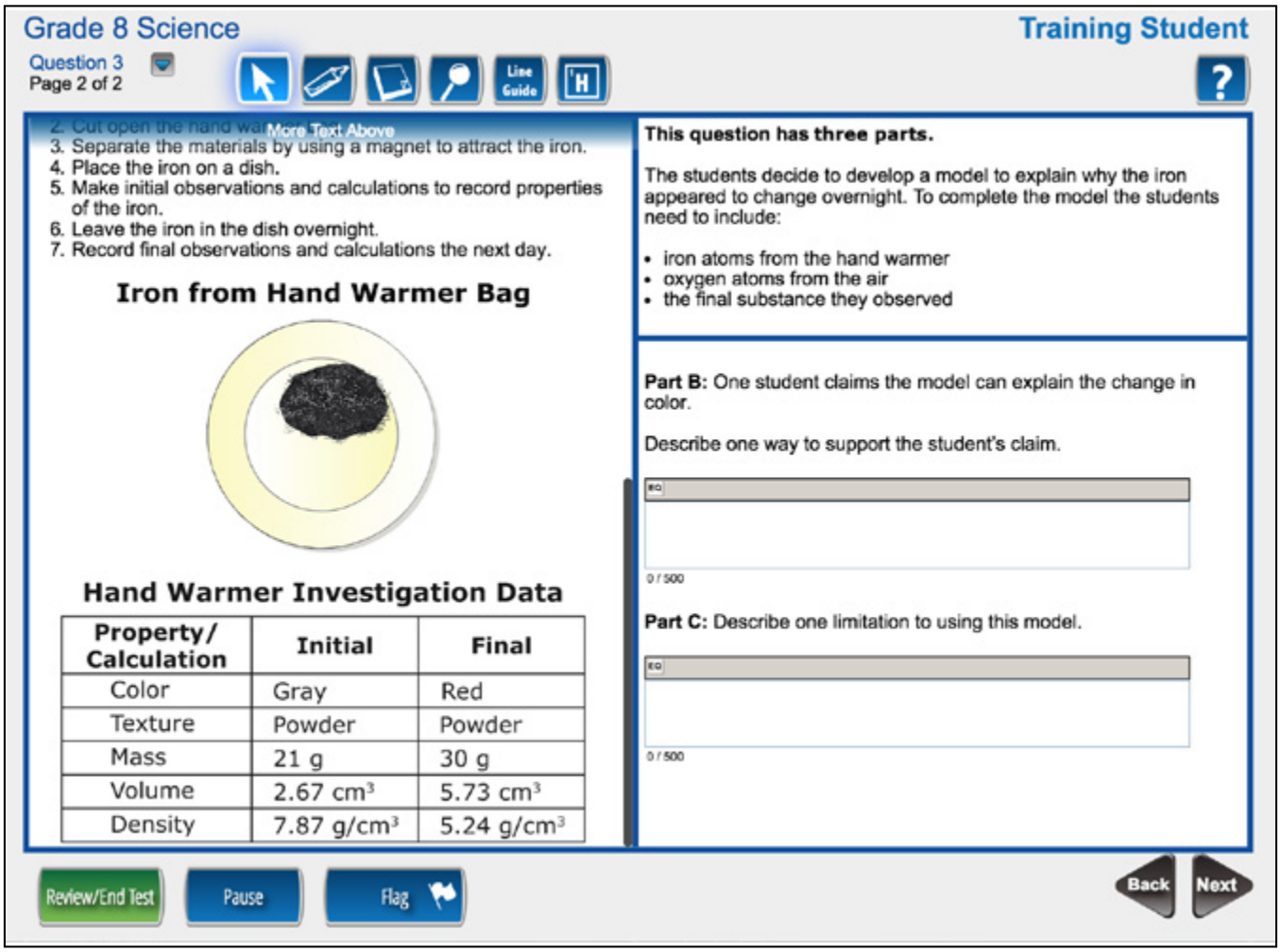
Grade 8 Sample Item Cluster: Handwarmers





The student selects "Click to Respond" to enlarge the response window, and then moves atom symbols into the model boxes to respond to the prompt.

Grade 8 Sample Item Cluster: Handwarmers



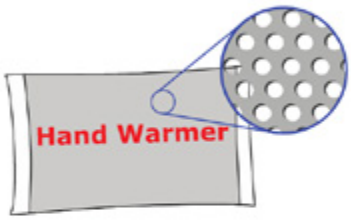
Part	Key	Scoring
A: Initial Iron Atoms (see model on previous page)	4 iron (Fe) atoms	*
A: Oxygen in the Air (see model on previous page)	6 oxygen (O) atoms	1
B	The model can explain a change in color because the model shows atoms recombining to form a new substance. Color change can happen when a new substance is formed.	1
C	One limitation of using this model is (answers may vary but could include): the colors of the atoms don't show the color turning to red; the oxygen atoms are in pairs before the reaction occurs; etc.	1
Assessment Claim: The student completes a model to show conservation of matter during a chemical reaction. The student then explains how the model shows a property change and the limitations of the model.		

Grade 8 Sample Item Cluster: Handwarmers

Grade 8 Science
Training Student
Question 4
Line Guide

How do Hand Warmers Work? (Part 2)

After observing what happens with the iron in the hand warmers, the students decide to work on improving the hand warmers to make them get warm faster. The students observe that the hand warmer bag is made of fabric containing tiny holes.



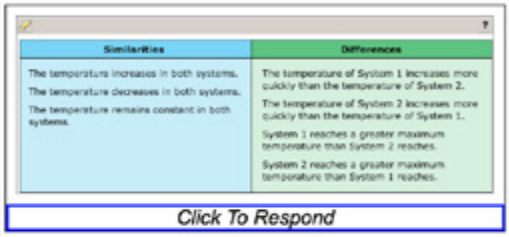
They think that if oxygen is needed to produce heat, maybe only a small amount of oxygen is getting through the fabric. To test this, the students design an investigation to record the change in temperature when the hand warmer ingredients are left in the hand warmer bag and when they are taken out of the hand warmer bag. The students set up two systems.

Investigation Plan

1. Open two hand warmer packages. Place one hand warmer bag on a dish labeled System 1.
2. Cut open the other hand warmer bag and pour the materials from inside the bag onto the dish labeled System 2.
3. Place a thermometer under the hand warmer bag in System 1 and a thermometer inside the materials in System 2.
4. Record the temperature of both systems every five minutes until one of the systems nears the starting temperature.

More Text Below

Compare the two sets of data in the graph. Select **two** similarities and **two** differences between System 1 and System 2.



Click To Respond

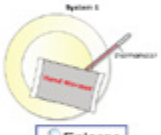
Review/End Test | Pause | Flag | Back | Next

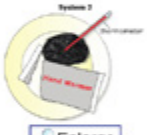
The student scrolls down to read the entire stimulus.

More Text Above

Investigation Plan

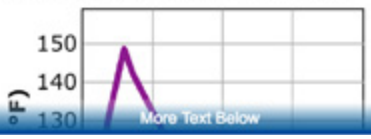
1. Open two hand warmer packages. Place one hand warmer bag on a dish labeled System 1.
2. Cut open the other hand warmer bag and pour the materials from inside the bag onto the dish labeled System 2.
3. Place a thermometer under the hand warmer bag in System 1 and a thermometer inside the materials in System 2.
4. Record the temperature of both systems every five minutes until one of the systems nears the starting temperature.


Enlarge


Enlarge

The temperature data from both systems are shown below.

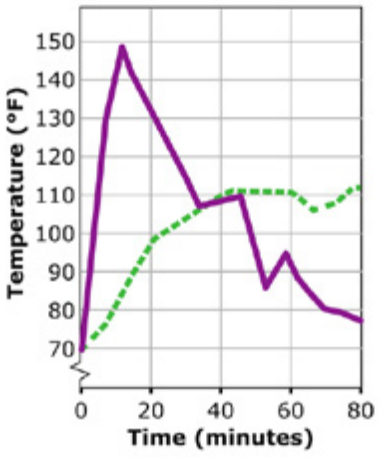
Temperature of System 1 and System 2 Over Time



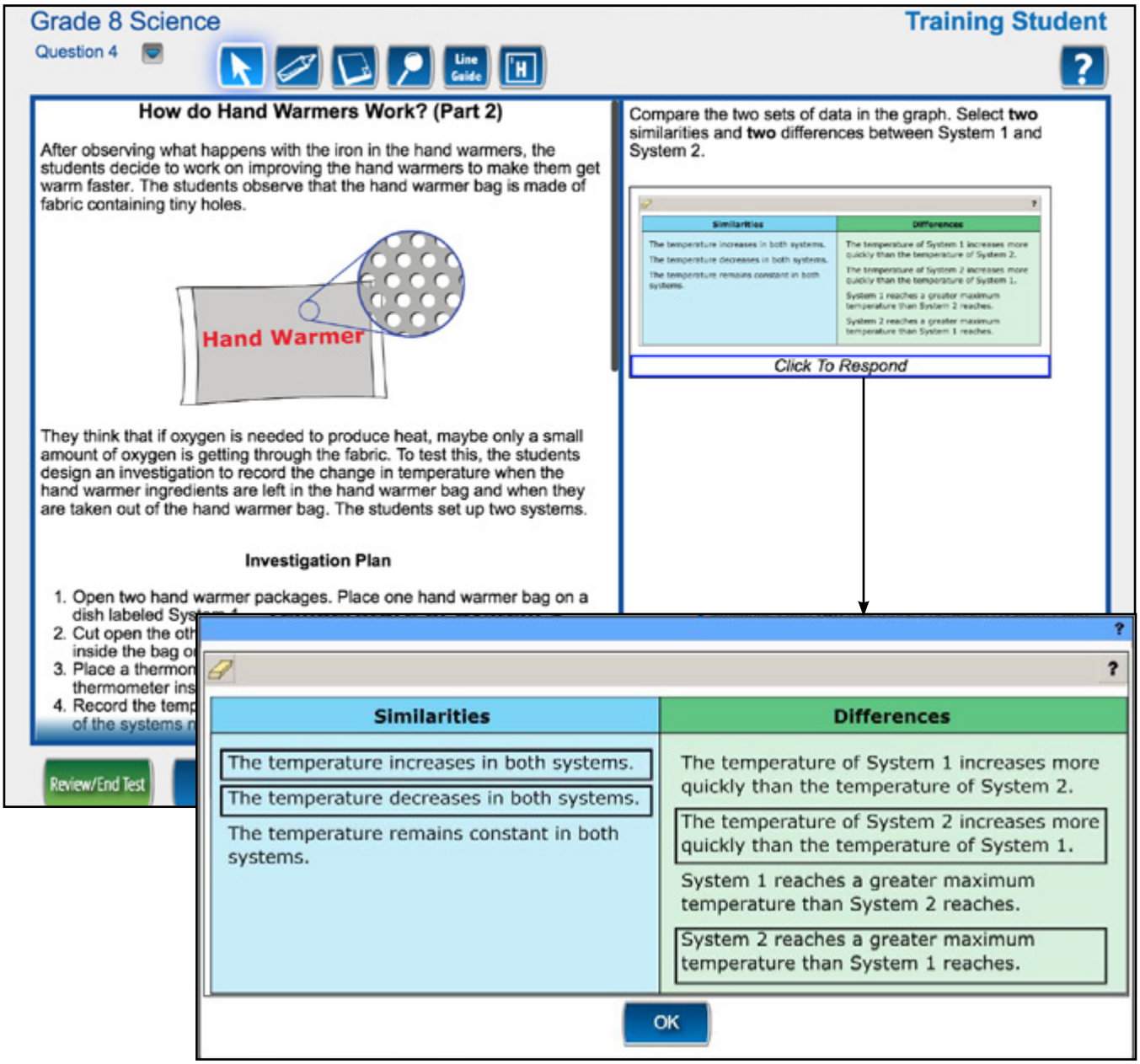
More Text Below

More Text Above

Temperature of System 1 and System 2 Over Time

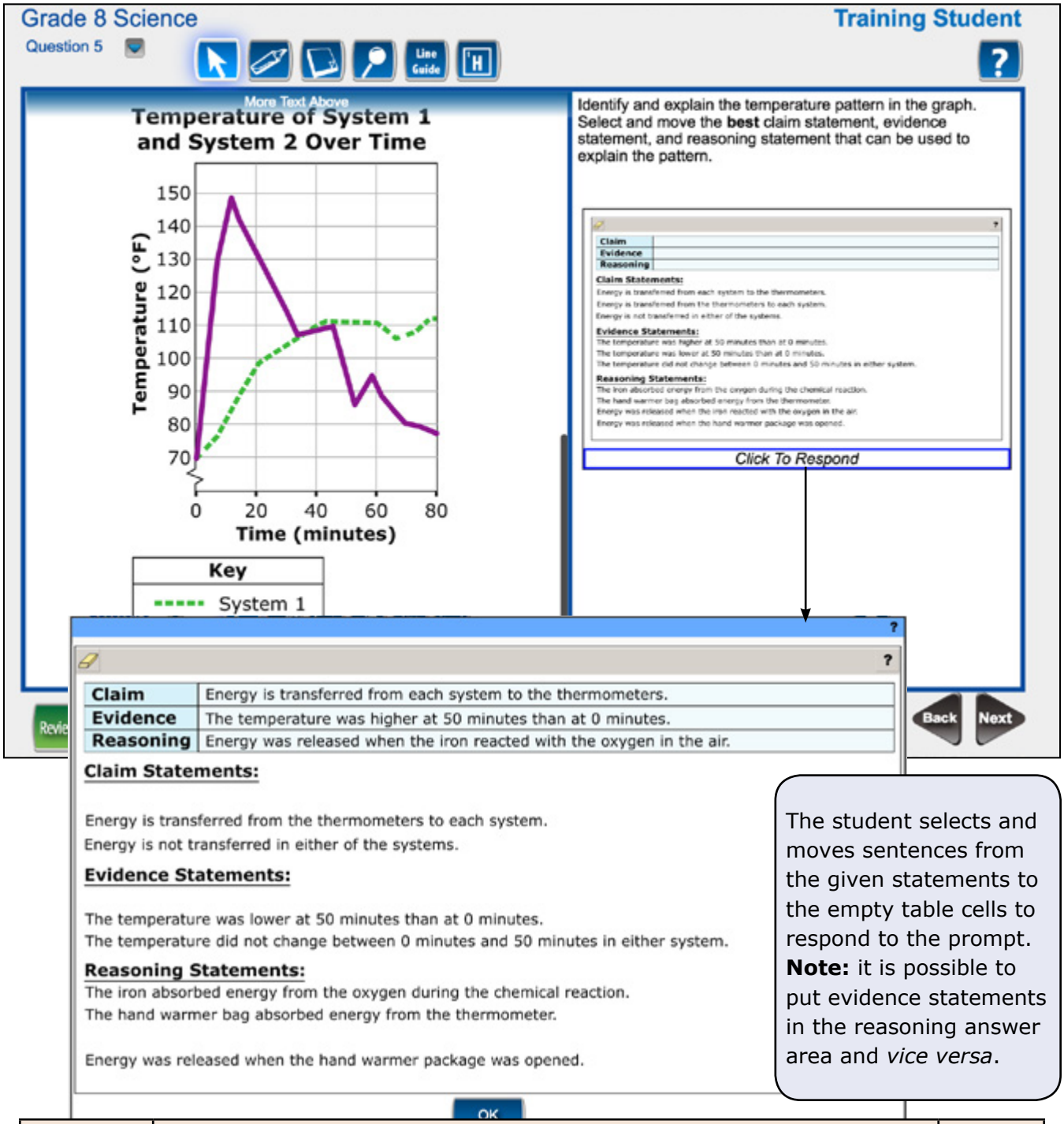


Grade 8 Sample Item Cluster: Handwarmers



Part	Key	Scoring
Similarities	The temperature increases in both systems.	*
Similarities	The temperature decreases in both systems.	*
Differences	The temperature of System 2 increases more quickly than the temperature of System 1.	*
Differences	System 2 reaches a greater maximum temperature than System 1 reaches.	1
Assessment Claim: The student compares the data for two systems.		

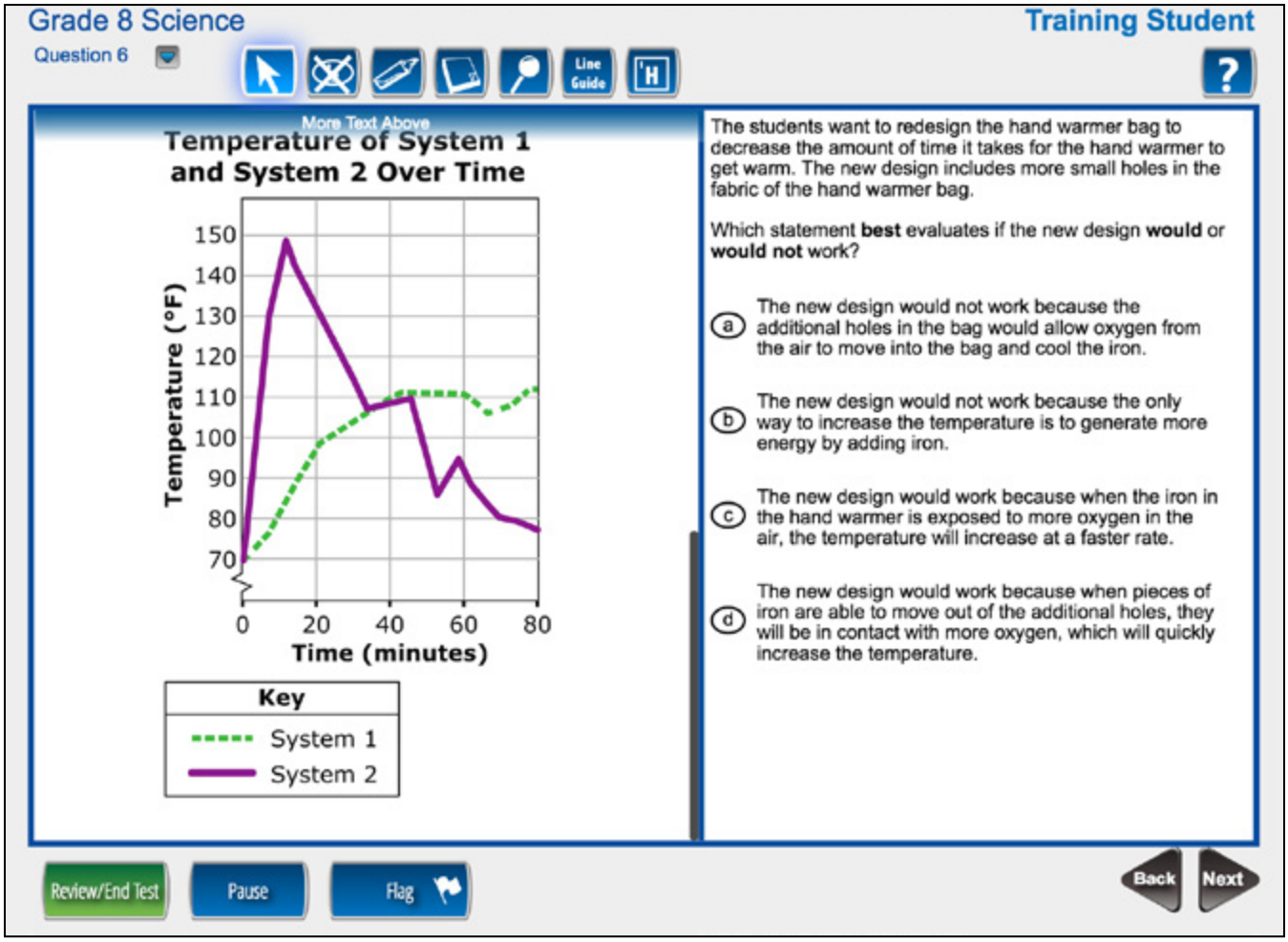
Grade 8 Sample Item Cluster: Handwarmers



The student selects and moves sentences from the given statements to the empty table cells to respond to the prompt. **Note:** it is possible to put evidence statements in the reasoning answer area and *vice versa*.

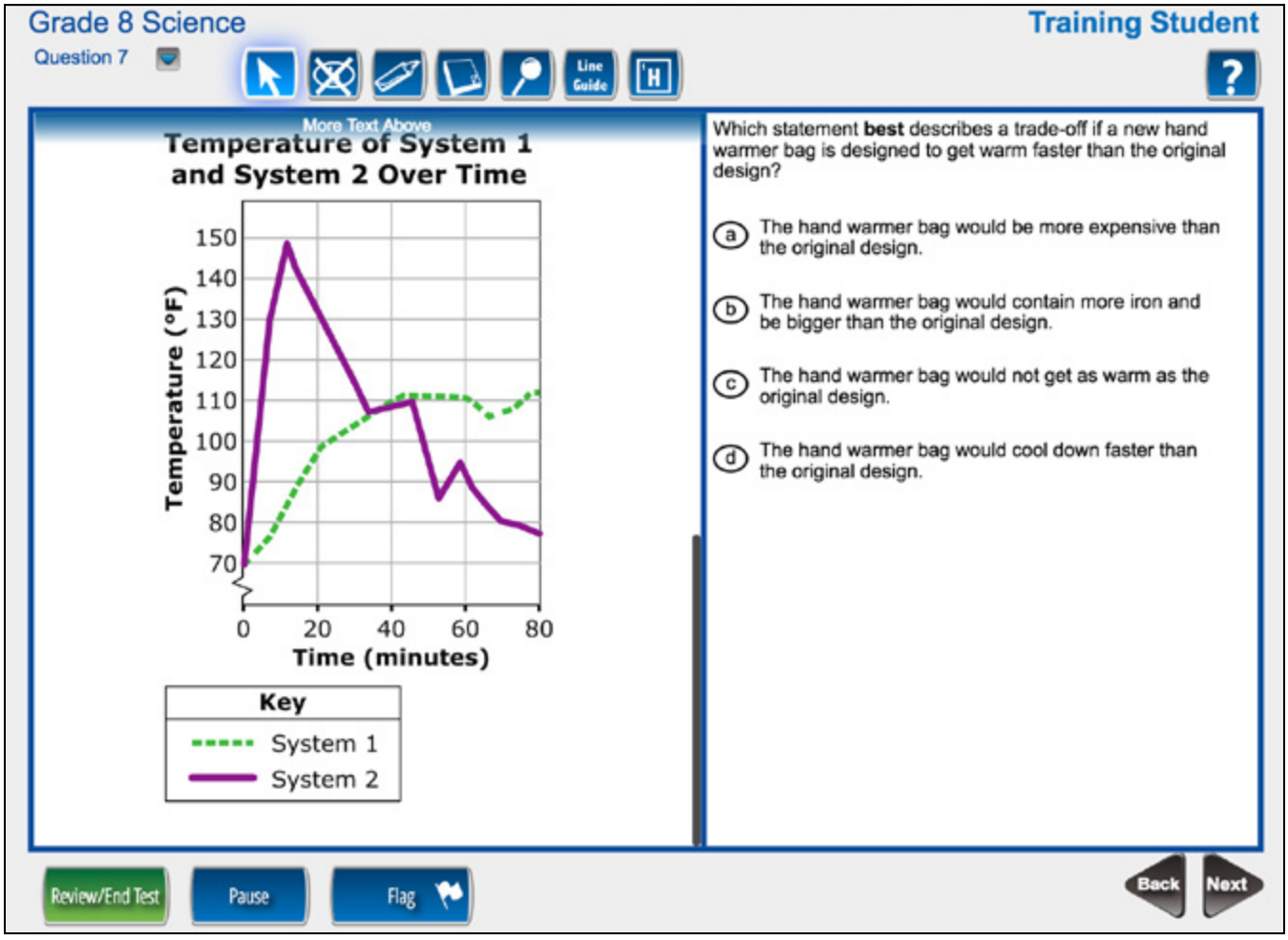
Part	Key	Scoring
Claim	Energy is transferred from each system to the thermometers.	*
Evidence	The temperature was higher at 50 minutes than at 0 minutes.	*
Reasoning	Energy was released when the iron reacted with the oxygen in the air.	1
Assessment Claim: The student constructs a scientific explanation about energy transfer in the system.		

Grade 8 Sample Item Cluster: Handwarmers



Part	Key	Scoring
NA	c	1
Assessment Claim: The student evaluates a design solution and determines if the design would or would not solve the problem.		

Grade 8 Sample Item Cluster: Handwarmers



Part	Key	Scoring
NA	d	1
Assessment Claim: The student evaluates a design solution and determines trade-offs of the design solution.		

Grade 11 SAMPLE ITEM CLUSTER: Atmospheric Changes over Time
Topic Bundle: Earth Systems Standards*

HS.Earth's Systems

HS.Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-2. **Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.** [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]

HS-ESS2-3. **Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.** [Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.]

HS-ESS2-5. **Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.** [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

HS-ESS2-6. **Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.** [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

HS-ESS2-7. **Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.** [Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3),(HS-ESS2-6)

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-ESS2-5)

Analyzing and Interpreting Data

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2)

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Construct an oral and written argument or counter-arguments based on data and evidence. (HS-ESS2-7)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes (HS-ESS2-2)
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)

ESS2.B: Plate Tectonics and Large-Scale System Interactions

- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3)

ESS2.C: The Roles of Water in Earth's Surface Processes

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2)
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6),(HS-ESS2-7)
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6)

ESS2.E: Biogeology

- The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-

Crosscutting Concepts

Energy and Matter

- The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6)
- Energy drives the cycling of matter within and between systems. (HS-ESS2-3)

Structure and Function

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7)
- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)

Connections to Engineering, Technology and Applications of Science

Interdepend
Engineering

- Science a
each othe
research
R&D proj
engineers
of experti

Influence of
and Science
World

- New tech
impacts on
environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions

Item alignment for DCIs requires that the item aligns directly with the element (bullet) displayed in the foundation boxes.

Item alignment for SEPs and CCCs does **not** require that the item aligns directly with the element (bullet) displayed in the foundation boxes but can align with **any** appropriate element listed as part of the SEP or CCC in Appendices F and G of the Next Generation Science Standards.

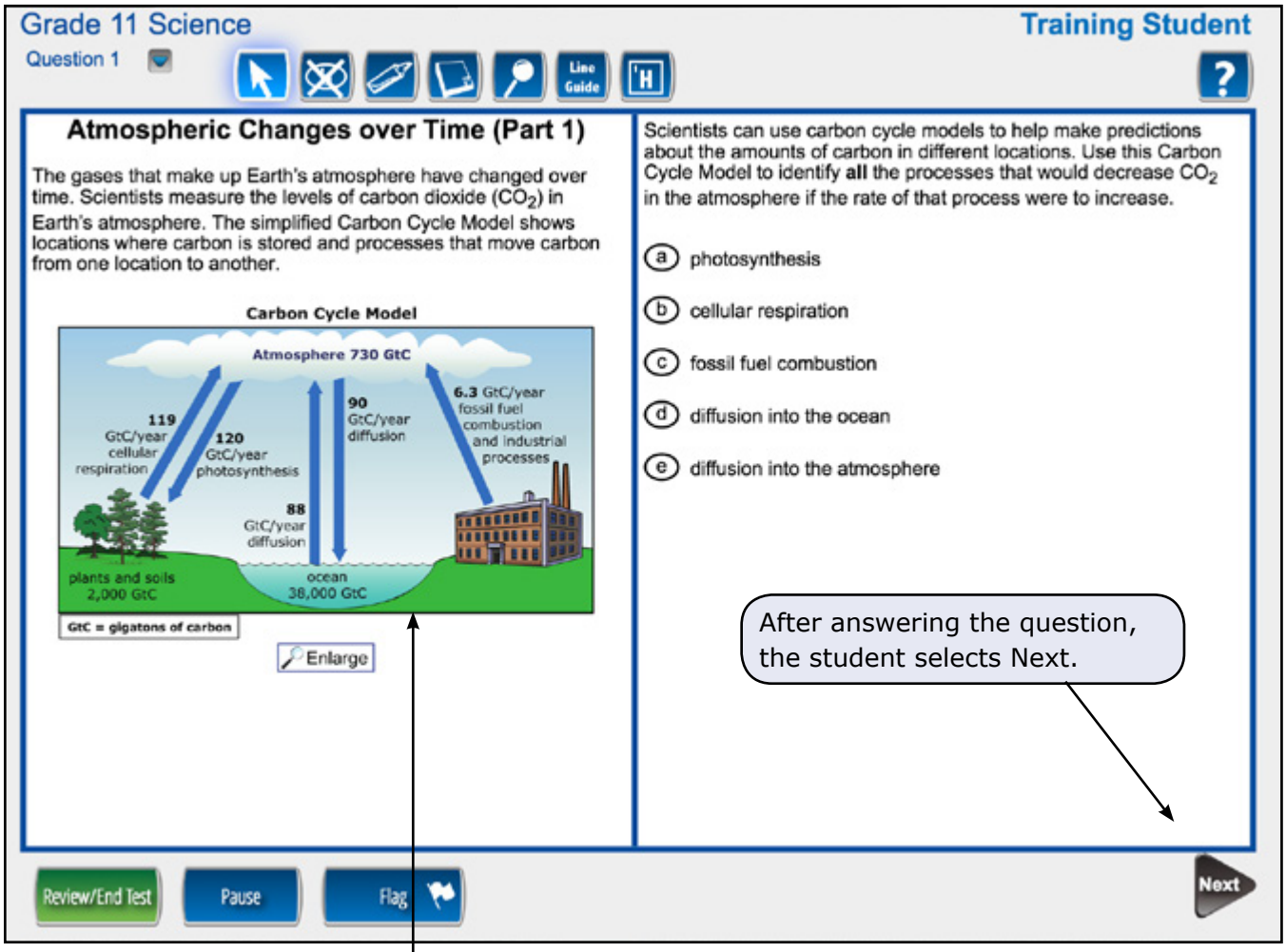
*NGSS Appendices (https://www.nextgenscience.org/resources/ngss-appendices)

Grade 11 Sample Item Cluster: Atmospheric Changes, Metadata Table

Phenomenon: Changes in carbon in atmosphere								
Stimulus or Item Part	Brief Description	Item Type	DCI	SEP	CCC	Points	Estimated Time (min)	Hand or Automated Scoring
Stimulus Part 1	Carbon cycle model	n/a	n/a	n/a	n/a	n/a	2	n/a
1	Process to decrease CO_2 in atmosphere	Multiple Select	ESS2.A	2	7	1	1	A
2	CO_2 concentrations over time	Drop-Down	ESS2.D	4	7	1	1	A
3	Changes in the atmosphere from early history	Drop-Down	ESS2.D	4	7	1	1	A
Stimulus Part 2	Solar radiation investigation	n/a	n/a	n/a	n/a	n/a	2	n/a
4a & 4b	Energy transfer in systems	Multiple Choice & Drop-Down	ESS2.C	3	5	1	2	A
5	Modify the investigation	Drag and Drop	ESS2.C	3	5	1	2	A
6	Sea ice and solar radiation absorption	Hot Spot	ESS2.D	4	7	1	1	A
7a & 7b	Atmosphere changes effect on polar bears	Drag and Drop & Constructed Response	ESS2.D & ESS2.E	7	7	3	3	H
		Total	**5/9**	**4/4**	**2/3**	**9**	**15**	

The DCI, SEP, and CCC totals refer to the number of the dimensions assessed in the item cluster compared to the number presented in the topic bundle.

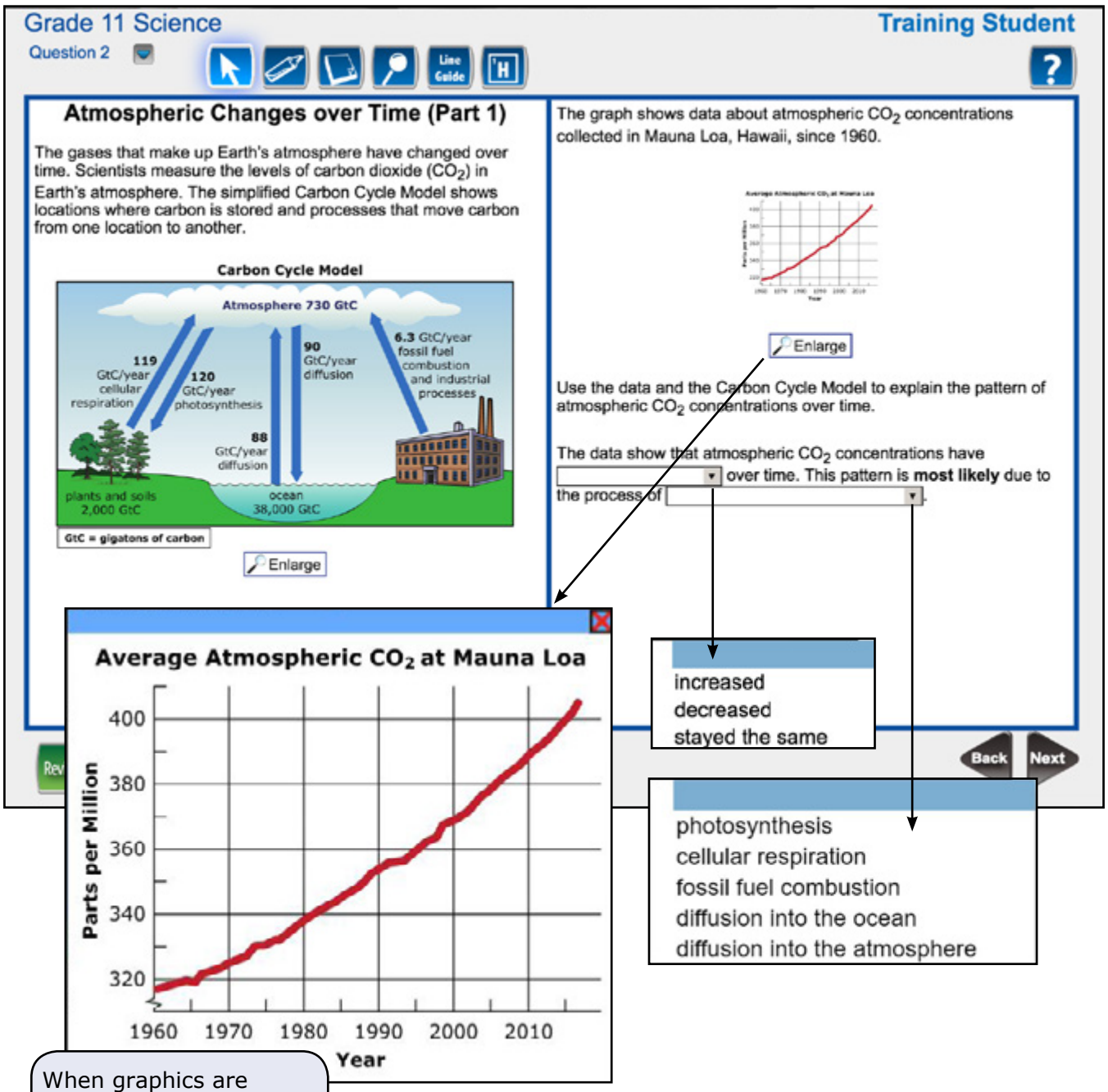
Grade 11 Sample Item Cluster: Atmospheric Changes



Part	Key	Scoring
NA	a and d	1
Assessment Claim: The student uses the model to make a prediction about how changes in parts of the carbon cycle would affect other parts of the cycle.		

Stimulus introduces the phenomenon and remains on the left side of the screen as the items change on the right side of the screen. The student may need to scroll down to read the entire stimulus.

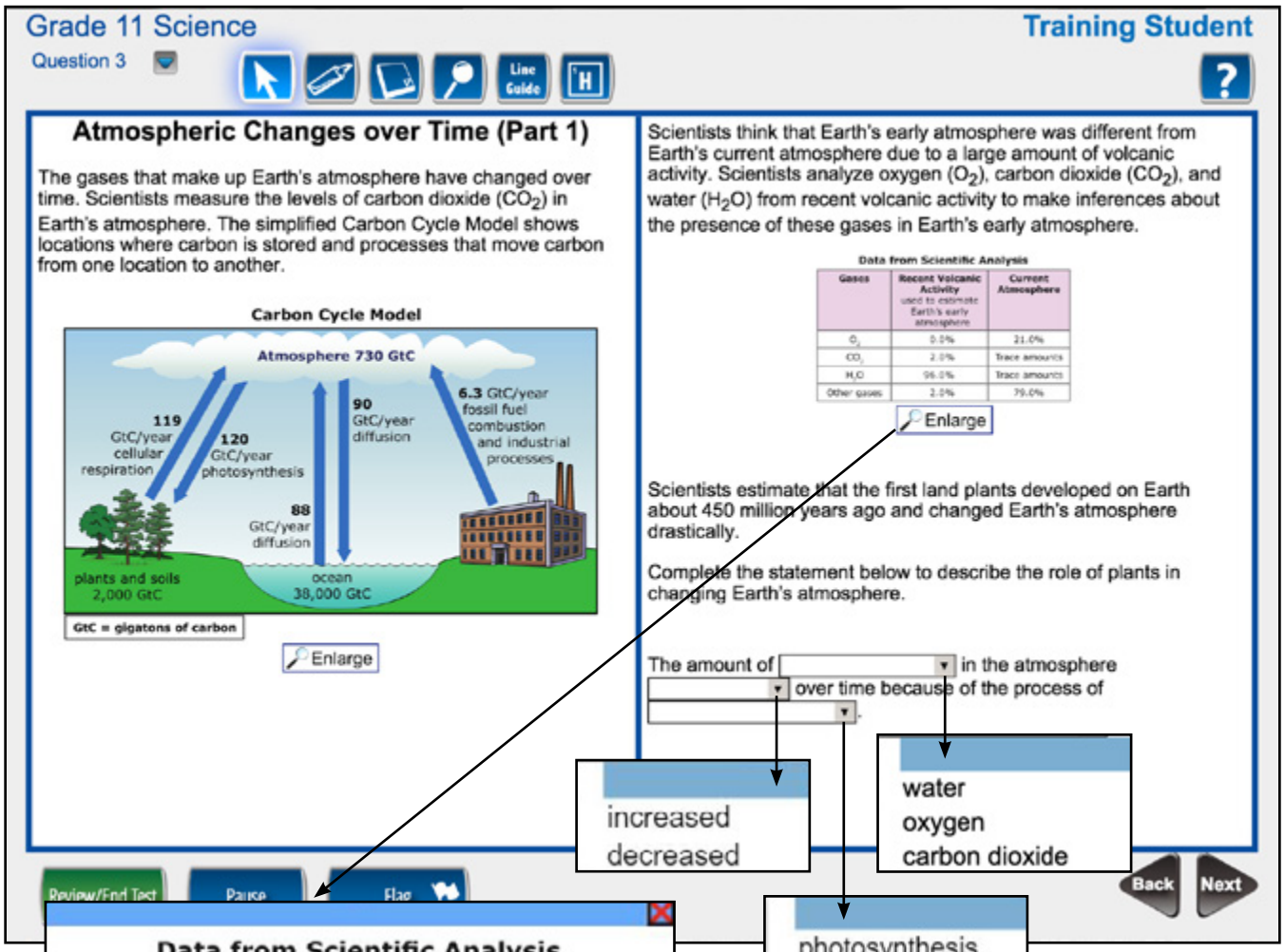
Grade 11 Sample Item Cluster: Atmospheric Changes



When graphics are enlarged they can overlap. The student can move the enlarged boxes around by selecting and holding on the blue bar at the top and moving the box.

Part	Key	Scoring
drop-down 1	increased	*
drop-down 2	fossil fuel combustion	1
Assessment Claim: The student uses the model and the data table to explain changes in atmospheric CO_2 concentrations over time.		

Grade 11 Sample Item Cluster: Atmospheric Changes



Data from Scientific Analysis

Gases	Recent Volcanic Activity used to estimate Earth's early atmosphere	Current Atmosphere
O_2	0.0%	21.0%
CO_2	2.0%	Trace amounts
H_2O	96.0%	Trace amounts
Other gases	2.0%	79.0%

Part	Key 1 (possible correct answers)	Key 2 (possible correct answers)	Scoring
drop-down 1	oxygen	carbon dioxide	*
drop-down 2	increased	decreased	*
drop-down 3	photosynthesis	photosynthesis	1
Assessment Claim: The student uses the model and the data table to explain changes in atmospheric O_2 concentrations over time.			

Grade 11 Sample Item Cluster: Atmospheric Changes

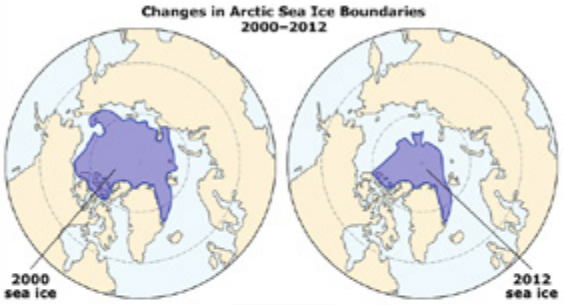
Grade 11 Science — Training Student

Question 4
Page 1 of 2

Atmospheric Changes Over Time (Part 2)

More Text Above

Students study how changes in Earth's atmosphere affect Arctic sea ice.



Enlarge

The students notice that the maps show liquid water and land in addition to sea ice. They perform an investigation to determine if solar radiation affects water and land differently.

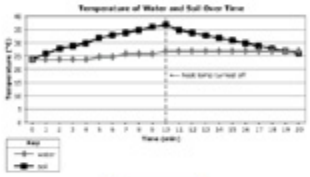
Investigation Materials
- water to model the ocean
- soil to model the land
- heat lamp to model the Sun
- equal volumes of water and soil

The heat lamp was turned on for 10 minutes and then turned off.

More Text Below

This question has two parts.

The graph shows the data collected during the investigation.



Enlarge

Part A: Based on the graph, which statement **best** explains the difference in the temperature pattern between the substances?

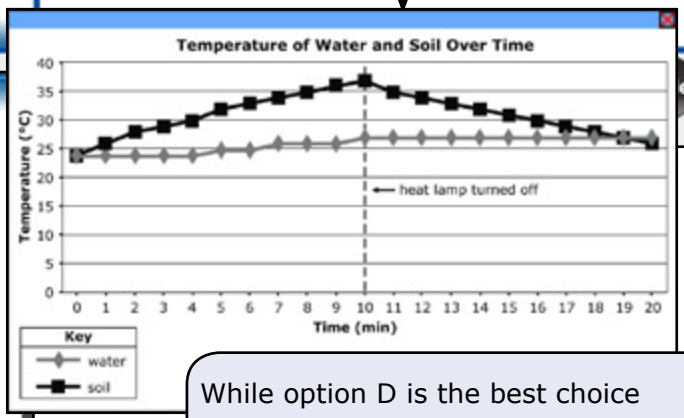
(a) Water absorbs and stores more energy than soil.

(b) Soil absorbs and stores more energy than water.

(c) Water absorbs more energy than soil but can quickly release the energy in a short period of time.

(d) Soil absorbs more energy than water but can quickly release the energy in a short period of time.

Next



More Text Above

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Investigation Materials
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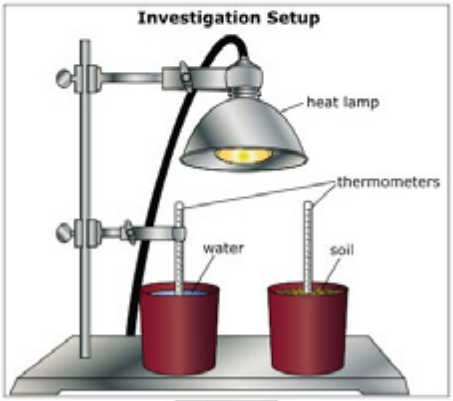
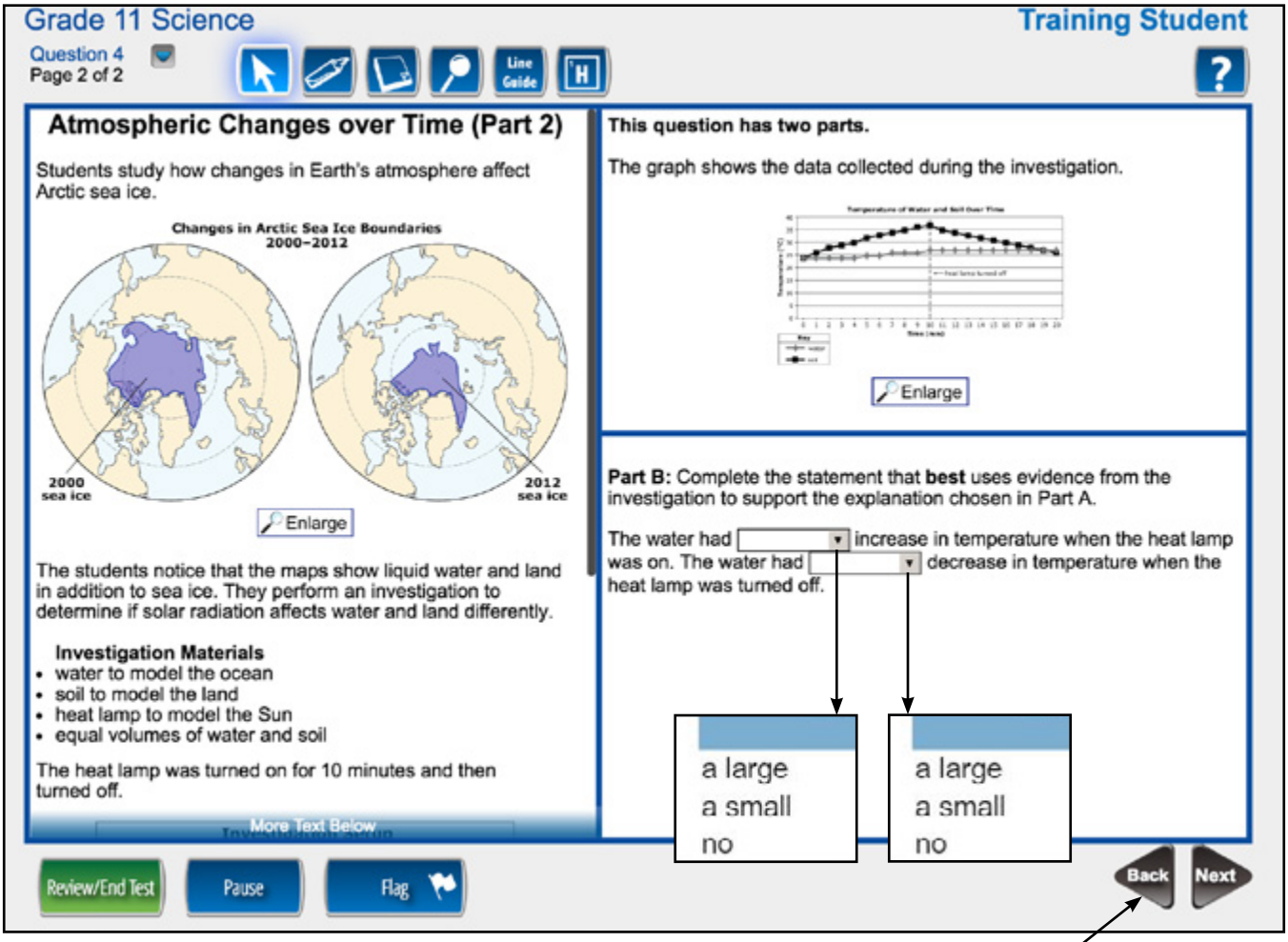


Enlarge

The student scrolls down to read the entire stimulus.

While option D is the best choice available, the key difference is that the same amount of energy causes a larger change in temperature for the soil, and that option is not available.
The amount of energy absorbed and stored in the two containers would depend on various factors (e.g., the color of the water container, the color of the soil, and rates of evaporation from the water.) Overall, the amount of energy absorbed and stored by the water and the soil is likely to be about the same.

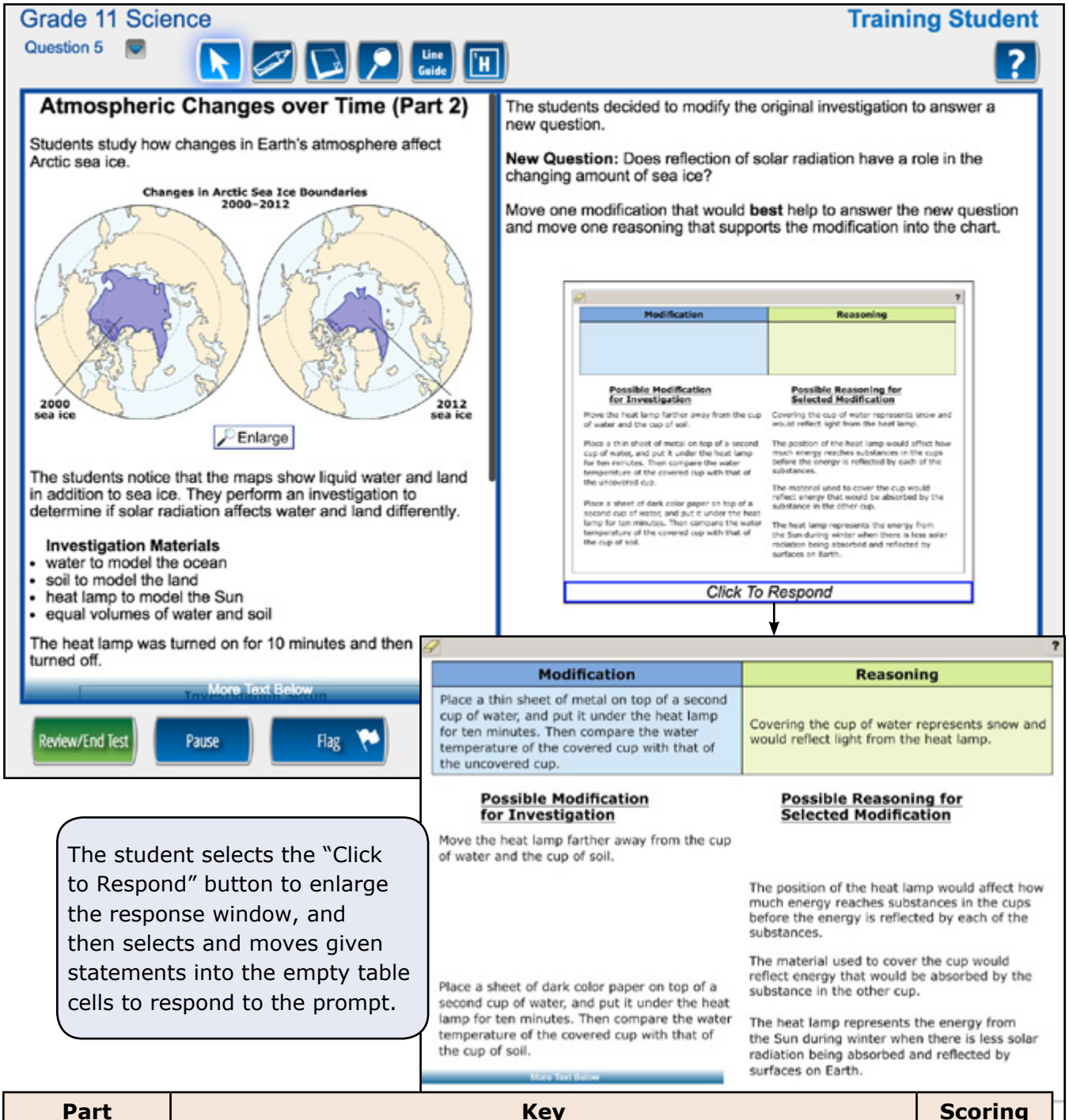
Grade 11 Sample Item Cluster: Atmospheric Changes



Part	Key	Scoring
A	d	*
B: drop-down 1	a small	*
B: drop-down 2	no	1
Assessment Claim: The student uses the data from the investigation to explain the difference in energy absorption of two materials.		

The student can navigate backward or move forward throughout the entire item cluster.

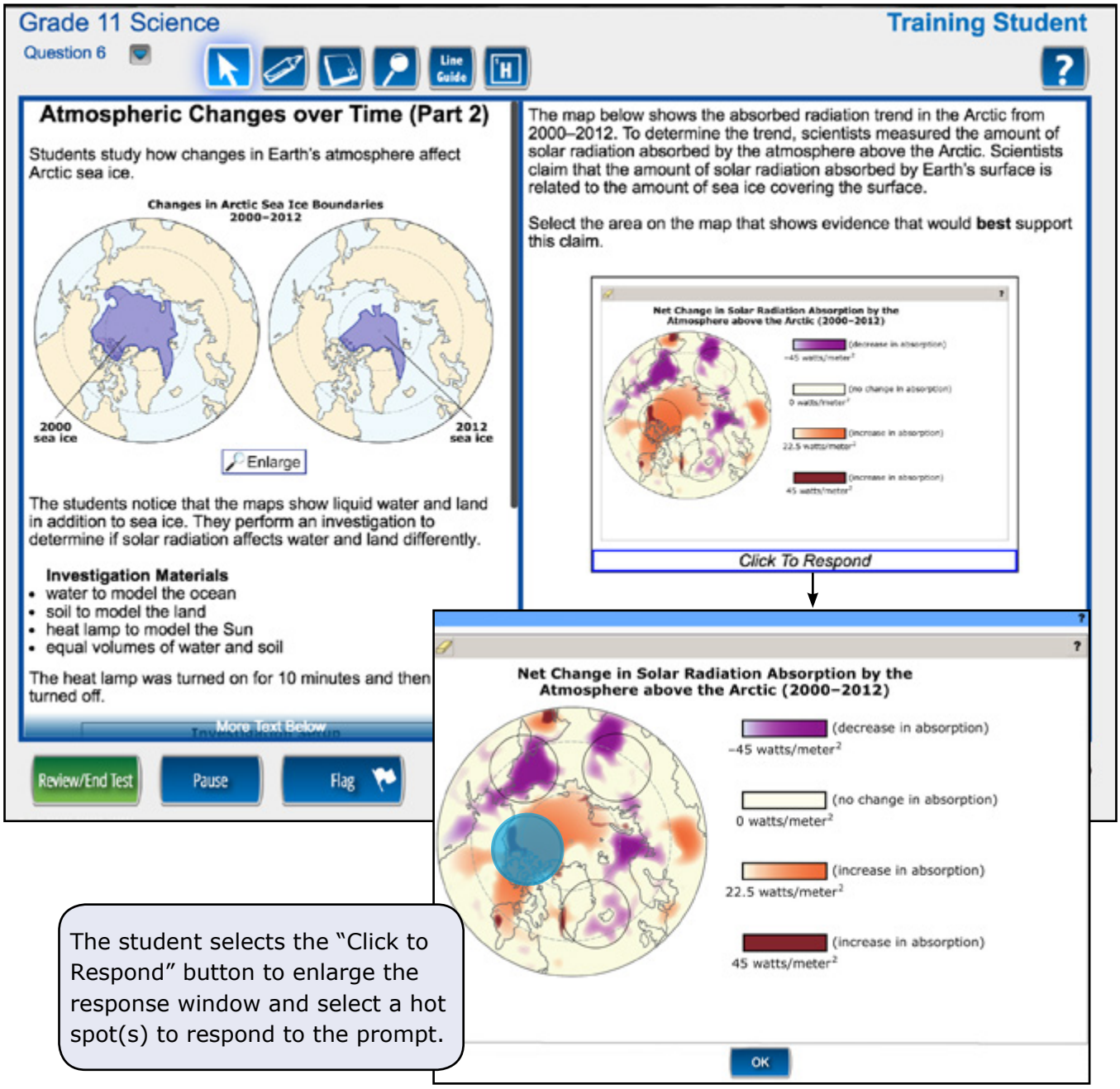
Grade 11 Sample Item Cluster: Atmospheric Changes



The student selects the "Click to Respond" button to enlarge the response window, and then selects and moves given statements into the empty table cells to respond to the prompt.

Part	Key	Scoring
Modification	Place a thin sheet of metal on top of a second cup of water, and put it under the heat lamp for ten minutes. Then compare the water temperature of the covered cup with that of the uncovered cup.	*
Reasoning	Covering the cup of water represents snow and would reflect light from the heat lamp.	1
Assessment Claim: The student determine how to modify the investigation to answer a new question.		

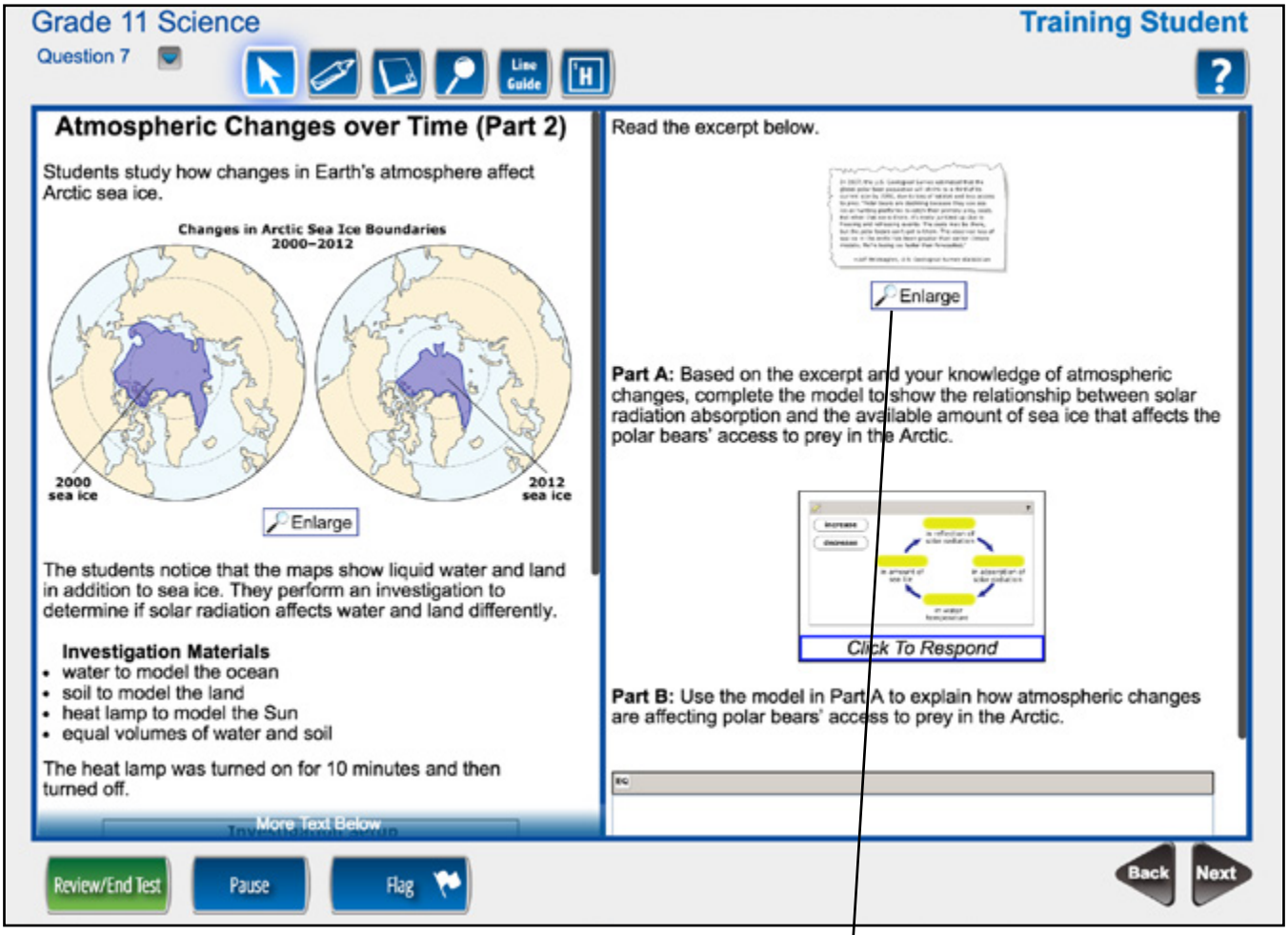
Grade 11 Sample Item Cluster: Atmospheric Changes

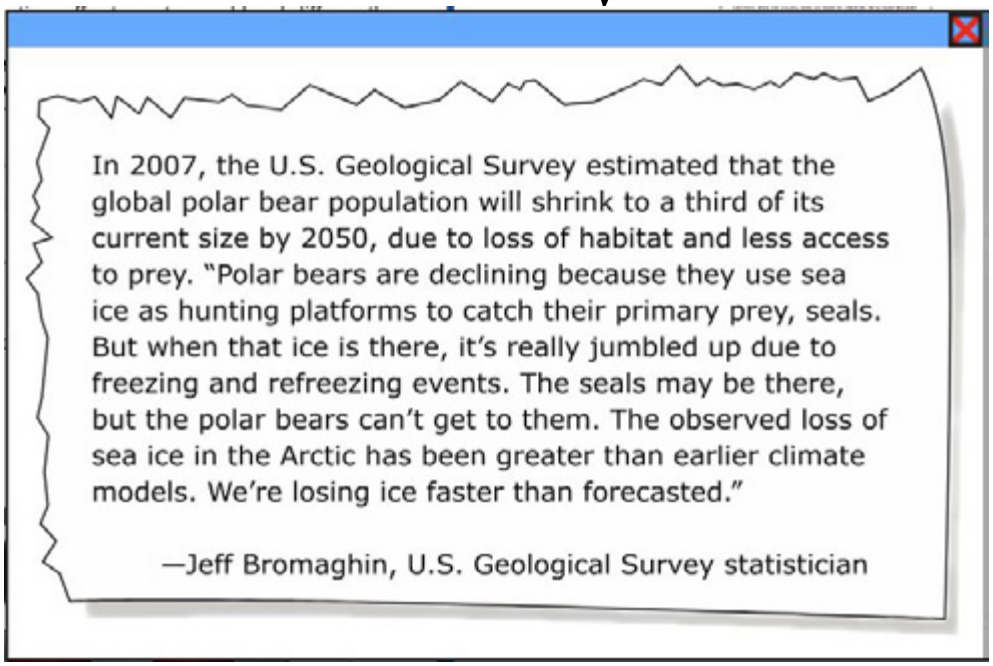


The student selects the "Click to Respond" button to enlarge the response window and select a hot spot(s) to respond to the prompt.

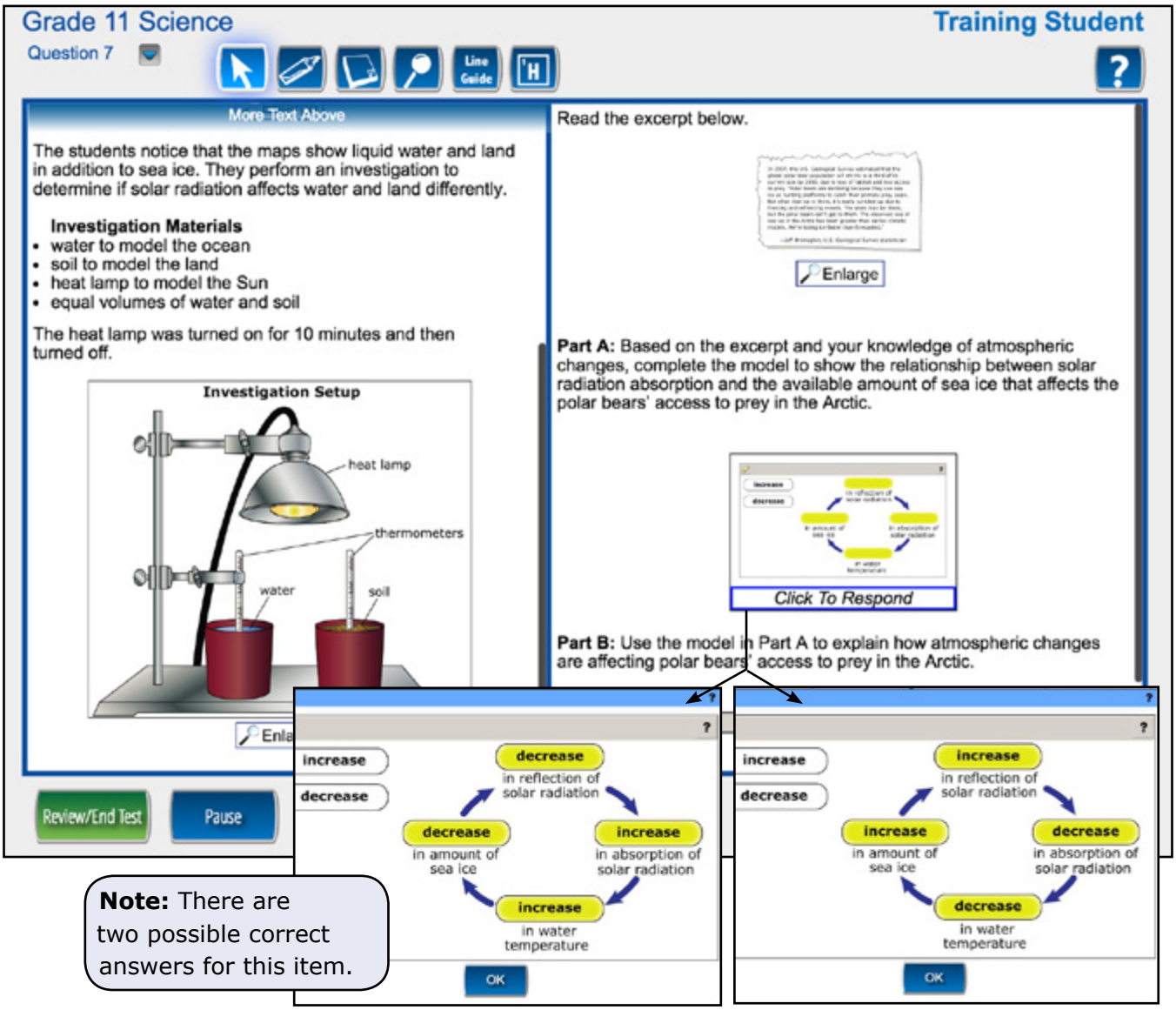
Part	Key	Scoring
NA	The area that is keyed to dark red (increase in absorption) 45 watts/meter^2	1
Assessment Claim: The student compares graphical information and extrapolates evidence to support a claim about trends in solar radiation absorption.		

Grade 11 Sample Item Cluster: Atmospheric Changes





Grade 11 Sample Item Cluster: Atmospheric Changes



Note: There are two possible correct answers for this item.

Part (model labels)	Key 1 (possible correct answers)	Key 2 (possible correct answers)	Scoring
A: top label	decrease	increase	*
A: right label	increase	decrease	*
A: bottom label	increase	decrease	*
A: left label	decrease	increase	1
B	The model shows a cycle of decreasing sea ice due to increased CO_2 in the atmosphere. The decrease in sea ice prevents polar bears from accessing their main prey, seals. Without access to prey, the polar bears will die off.		2
Assessment Claim: The student completes a model to show the relationship between solar radiation and amount of sea ice. The student then uses the model to construct an explanation about how the atmospheric changes are affecting polar bears.			

References

Michigan Department of Education. 2015. Michigan K-12 Science Standards. https://www.michigan.gov/documents/mde/K-12_Science_Performance_Expectations_v5_496901_7.pdf

National Research Council. 2012. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Washington, DC: The National Academies Press. https://doi.org/10.17226/13165.

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States.* Washington, DC: The National Academies Press.

5th

8th

11th

2018 Science
Grades 5, 8, and 11
Annotated Sample Items

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