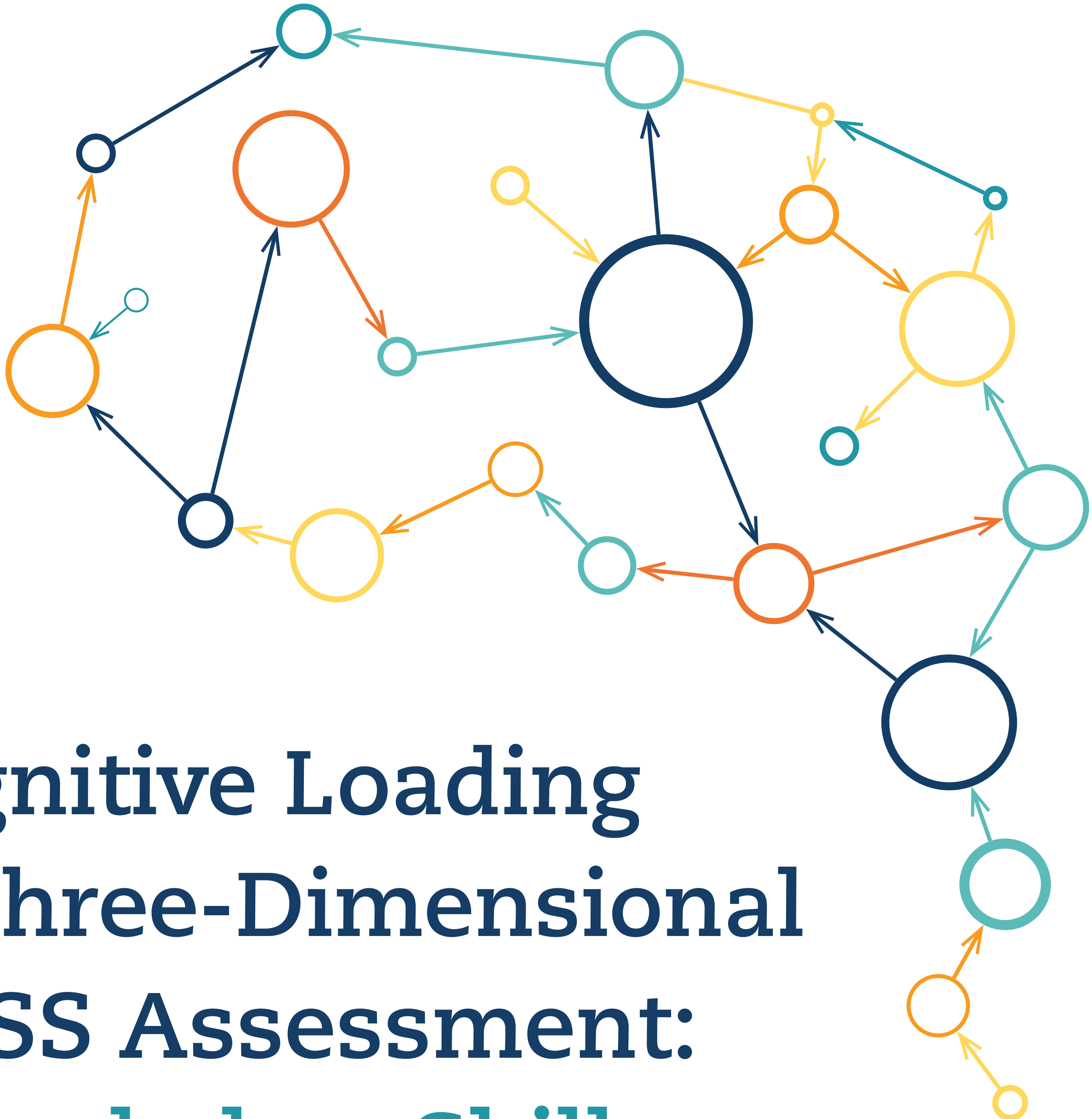

Cognitive Loading in Three-Dimensional NGSS Assessment: Knowledge, Skills, and Know-How

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THE CENTER ON STANDARDS & ASSESSMENT IMPLEMENTATION
WestEd CRESST

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INTRODUCTION

Conventional cognitive complexity models for large-scale assessments have lately been challenged by the expectations inherent in the Next Generation Science Standards (NGSS). An expectation of assessing science under the Every Student Succeeds Act (ESSA), and an expectation described in the peer review guidance for states is that any assessments that are developed, including those aligned to the NGSS, incorporate items representing a range of cognitive complexities. It is time to meet and address this latest challenge by identifying the need, recognizing current options, and outlining a viable path forward.

Developed as an instantiation of a framework for a way of thinking, doing, and knowing about the world, the NGSS are intended as both guideposts and end goals, setting the stage for how students come to understand the world around them. Performance expectations written for the NGSS incorporate three dimensions: science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs). The cognitive processes associated with each of the three dimensions are intended to be interwoven as a student engages in sense-making within the context of a unique scientific phenomenon. In addition, the core ideas included in the standards are organized around research comparing novice thinkers to expert thinkers (NGSS Appendix A, p. 2–3). According to the Framework for K–12 Science Education citing research from the National Research Council (1999):

> Experts understand the core principles and theoretical constructs of their field, and they use them to make sense of new information or tackle novel problems. Novices, in contrast, tend to hold disconnected and even contradictory bits of knowledge as isolated facts and struggle to find a way to organize and integrate them. (National Research Council, 2012, p. 25)

The goal of scientific instruction is for students to become more and more expert in their understanding, with the ability to understand core principles and theoretical constructs and use them to make sense of new information or to tackle novel problems. Students who have a more novice understanding may hold disconnected or contradictory knowledge as isolated information, and they struggle to find ways to organize and integrate their understanding into reference frames. When students learn the core ideas through engaging in scientific and engineering practices, they may become less like novices and more like experts (National Research Council, 2012, p. 25). When developing NGSS assessments, it is important to acknowledge the intent of the standards to facilitate student shifts from novice to expert and to identify the forms of evidence that would support those claims (Pellegrino, 2016).

The determination of what to assess holds consequence beyond simply gathering evidence in support of a claim. "What we choose to assess will end up being the focus of instruction" (Pellegrino, 2016, p. 1). In terms of the NGSS, this extends beyond the "what" to the "how" of what we assess. While it is true that assessments concentrating on content alone may lead to a focus on traditional rote content methodologies in the classroom, it is also true that assessment items that integrate the three dimensions of science, while also incorporating guided assistance for the student in the form of heavy scaffolding, may lead to pedagogies that rarely encourage sense-making or autonomous problem solving. If the goal of the NGSS is to move students toward more expert levels of thinking, it is important that assessments survey a range of levels of thinking and reasoning.

Cognitive complexity scales modeled from Bloom's taxonomy identify individual cognitive processes such as remembering, applying, analyzing, and evaluating. Similar systems were conveniently carried over to past iterations of large-scale science assessment. Such taxonomies illustrate individual categories of knowledge and skill activities as they increase in complexity; one level leading to the next in a linear progression. But the NGSS, with their integration of SEPs, DCIs, and CCCs, assume a multi-dimensional approach to addressing natural and/or engineered phenomena. Tasks associated with the NGSS benefit from a model of cognitive complexity that recognizes the demand created by this multi-dimensionality as opposed to by singular processes. This paper presents a new model for evaluating the cognitive ranges of large-scale assessment specific to the NGSS.

BACKGROUND

The Next Generation Science Standards require an integration of three overarching dimensions of understanding: Scientific and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. Assessing such standards requires "assessment tasks that examine students' performance of scientific and engineering practices in the context of crosscutting concepts and disciplinary core ideas" (National Research Council, 2014, p. 44).

The 2001 Committee on the Cognitive Foundations of Assessment (National Research Council, 2001) describe assessment as "a process of reasoning from evidence—of using a representative performance or set of performances to make inferences about a wider set of skills or knowledge" (National Research Council, 2014, p. 48). In developing this description, the panel outlined a triangle resting on cognition in one corner, or the "theory or set of beliefs about how students represent knowledge and develop competence in a subject domain" (National Research Council, 2014, p. 44). A second corner of the triangle is observation of student capabilities, while the third corner is interpretation of those observations. *For the NGSS, the cognition to be assessed consists of the SEPs, the CCCs, and the DCIs as they are integrated in the performance expectations—or as they are applied to the context of a scientific phenomenon* (National Research Council, 2014).

To adequately provide evidence of proficiency along a continuum of cognitive complexity for students interacting with the NGSS, it is necessary to identify an evaluative scale that goes beyond a singular focus and recognizes the three-dimensionality of the NGSS and its application to novel phenomena. It is appropriate to recognize the effect of innate content difficulty along with the level of strategy independence (problem solving) and information processing required of the learner under such three-dimensional circumstances. In evaluating ranges of cognition for the NGSS, it is time to consider cognitive load.

Why Cognitive Load?

Bloom's taxonomy, and many categorical approaches based on it, evaluates individual cognitive actions (e.g., application, evaluation, analysis). These actions are dependent upon the nature of the situation in determining the level of cognitive demand. Research by Paas, Renkl, and Sweller (2003) explains that cognitive demand is largely dependent upon the similarity of tested situations with prior learning experiences, as well as the overall complexity of the testing circumstance. Evaluations using these scales are often linear with a great deal of qualitative discussion among participating panelists.

Cognitive load refers to the amount of working memory resources used in completing a task (Sweller, 1988). In cognitive science, reasoning, decision-making, and the manipulation of recently stored (new) information are all attributed to working memory (Diamond, 2013; Sweller, van Merrienboer, & Paas, 1998). Traditional cognitive evaluations would indicate that each of the three NGSS dimensions within a performance expectation has its own individual level of complexity when observed as a separate entity. Each dimension incorporates individual elements of learning, defined by Sweller as "any material that needs to be learned" (Sweller, 1994, p. 304). Each dimension represents an individual element of learning and a cognitive action which can be performed or assessed at a different level of complexity within a task or problem. When the dimensions are integrated in a manner that requires simultaneous assimilation (as in a performance expectation), the elemental interactions increase within the working memory of the performer. Under these circumstances, the task cannot be completed without utilizing and simultaneously connecting the three dimensions (Sweller, 1988).

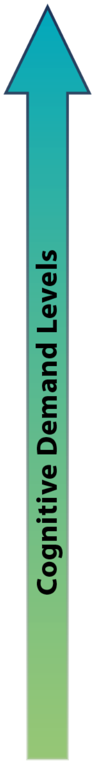
In terms of the NGSS, individual cognitive actions are merely a part of the overall cognitive load of any given performance expectation. By making combined use of SEPs, DCIs, and CCCs (which is the basis of NGSS expectations), students are asked to extend their working memory in action by engaging the skills and knowledge associated with science and engineering practices (SEPs) and scientific content (DCIs) through an organizing frame (CCCs). Students are additionally asked to employ these cognitive actions in the context of a scientific phenomenon that is different from those presented during instruction. Sweller, van Merrienboer, and Paas (1998) explain that such novel problems, having no previously constructed schema for a solution, present a significant cognitive load. By 2003 such elemental interaction was described as an architecture combining working and long-term memory to support the task. For novel problems, working memory allows for the interaction of one to three novel interacting elements (these are the three dimensions in the case of the NGSS), while long-term memory allows for the schemas, or cognitive constructs, that organize multiple elements of information (NGSS dimensions) into a single working element with a specific function—solving the novel/complex problem or phenomenon (Paas, Renkl, & Sweller, 2003). The level of scaffolding, or guided assistance, provided to support any or all the cognitive actions can increase or decrease the cognitive load extrinsically (Sweller, van Merrienboer, & Paas, 1998). Cognitive load, as articulated here, provides a multi-dimensional perspective of intellectual activity as expected by the NGSS.

A GUIDE FOR EVALUATING COGNITIVE LOAD

To appropriately assign cognitive load to three-dimensional assessment items prepared for standards such as the NGSS, it is important to recognize the interplay of the three dimensions, the degree of autonomy with which students apply the dimensions in exploring and explaining phenomena (i.e., sense-making), and the dimensions' connection with the context of the problem presented for student interaction.

Miray Tekkumru-Kisa, Mary Kay Stein, and Christian Schunn (2015) have developed a Task Analysis Guide in Science (TAGS), which addresses five levels of cognitive demand. The guide is shown in Figure 1 and was developed to be an analytical tool for educational researchers and practitioners analyzing science tasks and instruction.

Figure 1: Task Analysis Guide in Science



		Scientific Practices (e.g., argumentation and investigation)	**Science Content** (e.g., scientific body of knowledge)	**Integration of Content and Practices**
5	**Doing Science Tasks**			**Doing Science (DS)** Engaging in practices to make sense of content and recognize how scientific body of knowledge is developed
4	**Tasks Involving Guidance for Understanding**			**Guided Integration (GI)** Guidance for working with practices tied to a particular content
3		**Guided Practices (GP)** Being guided for understanding practices	**Guided Content (GC)** Being guided for understanding particular content	
2	**Tasks Involving Scripts**	**Scripted Practices (SP)** Following a script to work on practices	**Scripted Content (SC)** Following a script about a content	**Scripted Integration (SI)** Following a script to work on practices tied to content
1	**Memorization Tasks**	**Memorized Practices (MP)** Reproducing definitions/explanations of practices	**Memorized Content (MC)** Reproducing definitions, formulas, or principles about particular content	

Source: Journal of Research in Science Teaching

The TAGS guide has been modified for assessment use in Delaware (known as Modified TAGS or MTAGS) to categorize NGSS-aligned assessment items along a cognitive load continuum. As shown in Figure 2, the MTAGS guide focuses on the Integration of Content and Practices portion of the TAGS.

Figure 2: **Modified TAGS**

Increasing Cognitive Load →

↑ **Increasing Cognitive Load**

	One Dimension	Two Dimensions*	Three Dimensions
Doing Science Tasks	*N/A—a student cannot "do" science with only one dimension.*	Student engages in two dimensions to make sense of content and/or recognize how the scientific body of knowledge is developed. **CODE: DI2**	Student engages in three dimensions to make sense of content and/or recognize how the scientific body of knowledge is developed. **CODE: DI3**
Guided Tasks	Student is given some guidance or scaffolding with only a practice to complete OR is provided guidance toward supplying appropriate content as an answer.	Student is given some guidance or scaffolding to use two dimensions to complete a task. **CODE: GI2**	Student is given some guidance or scaffolding to use three dimensions to complete a task. **CODE: GI3**
Scripted Tasks	Student follows a script (outline) of a practice OR is told how to use a content to solve a problem.	Student follows a script to work with (or is told how to use) two dimensions to complete a task. **CODE: SI2**	Student follows a script to work with (or is told how to use) three dimensions to complete a task. **CODE: SI3**
Memorized Tasks	Student repeats or has to provide definition of practices or content.	*N/A—memorization cannot be complete where integration of dimensions is required.*	*N/A—memorization cannot be complete where integration of dimensions is required.*

*Two-dimensional combinations may include: SEP/DCI; SEP/CCC, or CCC/DCI

Grey columns/rows/cells are not intended for inclusion in NGSS-aligned assessments

The approach of the MTAGS to cognitive load accounts for the number of dimensions to which an item is aligned. To adequately assess NGSS, every item must be an integration of at least two of the three dimensions (SEP, DCI, and CCC). An item's cognitive load, however, is a combination of the level of independence required of the student in responding to the item and the level of integration of dimensionality. For example, an item with a script, such as a task outlining the procedure for determining density of a substance and asking a student to identify what the substance is by comparing the answer with a density chart, if aligned to an SEP and a DCI, would have a cognitive complexity designation of Scripted Integration 2 (SI2). An item with some scaffolding but without direct instructions for completing the task that was still only aligned to two dimensions would have a cognitive complexity designation of Guided Integration 2 (GI2).

The categories of cognitive complexity are summarized in Figure 2. The cognitive complexity of an item increases from bottom to top, from Scripted to Guided to Doing Science tasks. Cognitive complexity also increases from left to right with the increased integration of the dimensions, from the integration of two dimensions (SI2, GI2, or DI2) to the integration of three dimensions (SI3, GI3, or DI3). Items are developed across the range of cognitive complexities to support the goal of representing a range of cognitive complexity across each assessment.

The MTAGS approach outlines the expectation of a student's ability to access long-term memory schemas (scripted, guided, doing) as well as the interaction of working memory (one, two, or three dimensions). Item banks using the MTAGS system can monitor cognitive load in terms of the expectation of student independence in accessing tasks, while also noting the level of content and practice integration required for the development or design of a solution to the problem/question. In large-scale assessment settings, a healthy item bank, containing few scripted items, a robust pool of guided items, and a limited pool of doing science items would be an appropriate representation of a "range of cognitive complexities" as established and described by the NGSS.

Presented in Figure 3 is a sample Delaware item with an annotation of the MTAGS application to the item. Delaware's NGSS assessments are developed using standalone items aligned to a single PE and item clusters aligned to a PE bundle. Each item cluster contains multiple items and references a common stimulus. Each item within an item cluster is developed to a PE within the bundle and is written at a specific level of cognitive complexity. Each item functions as an independent measure within the cluster. An entire item cluster from the grade 5 practice test can be found in Appendix A. The appendix presents a full item cluster with each item annotated using the MTAGS model. This is presented to give some practical application to the model as it is presented. As with all item alignment judgments, we hope this appendix will provide the opportunity for readers to experience how the model is intended to be used, and also to engage in critical conversation about the application.

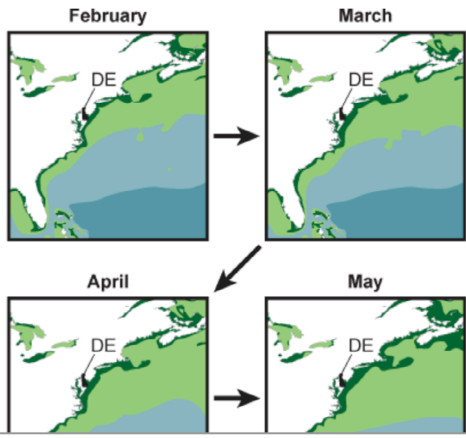
Figure 3: Grade 5 Practice Test Item with Annotation

Use the information in the tabs to answer the questions.

Tab 1—Ocean Ecosystem | Tab 2—Seasonal Changes | Tab 3—Algae | Tab 4—Fall Migration

The scientists made the maps in **Figure 3** to show how the amount of algae in the North Atlantic Ocean changes from February to March to April and to May. The location of Delaware is shown on each map.

Figure 3. Algae in the North Atlantic Ocean

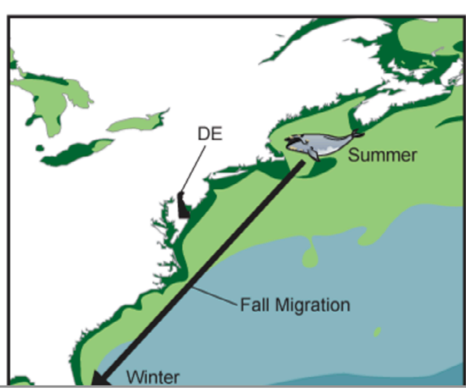


Tab 1—Ocean Ecosystem | Tab 2—Seasonal Changes | Tab 3—Algae | Tab 4—Fall Migration

Right whales migrate along the coast as the amount of energy and matter in an area changes.

Figure 4 shows the location of the whales during the summer, their path as they migrate south in the fall, and their location during the winter. The whales are much bigger when they leave their summer location than when they first arrived in that location. Their bigger size helps the whales migrate during the fall.

Figure 4. Fall Migration



Use the information in Tab 3 and Tab 4 to help you answer this question.

Construct an explanation of why the whales are much bigger at the end of summer than when they first arrived. Support your explanation with evidence collected from **Figure 3** and **Figure 4**.

B I U 1000

This practice item is an extended-response item asking students to construct an explanation (SEP) using the crosscutting concepts of systems and system models (provided in the stimulus) and applying the core idea of interdependent relationships in ecosystems (DCI). In this case, the item indicates, both in specific instructions before the item and within the item, that the student is to use information from specific sources within the stimulus—which is a form of scaffolding in the use of model access and explanation building. The item does NOT tell the student what information to look for, how to organize the information, or what information is relevant to a correct response. In this case the item would receive a cognitive code of **GUIDED** with the **INTEGRATION of 3 DIMENSIONS** or **GI3**.

USE OF MTAGS IN DELAWARE'S SCIENCE ASSESSMENT SYSTEM

The Delaware Department of Education's (DDOE) comprehensive science assessment system for grades 3–10 consists of three distinct types of assessments (see Appendix B). Under this system throughout the academic year, students take teacher-developed *Embedded Classroom Assessments* to provide formative information on learning in real time, *End-of-Unit Assessments* that are taken shortly after the completion of each instructional unit, and for students completing grade 5, grade 8, or high school biology, a summative *Integrative Transfer Assessment*. These Integrative Transfer Assessments (ITAs) capture students' learning of the content instructed during the entire year and in greater depth than the End-of-Unit (EoU) Assessments. The ITAs are used to meet federal requirements under ESSA.

The ITAs are made up of item clusters and standalone items. The approach taken by Delaware for item clusters reflects the recommendations laid out within the *Science Assessment Item Collaborative Assessment Framework for the Next Generation Science Standards* (SAIC Assessment Framework, 2015). Each item within an item cluster must be either two- or three-dimensional. When considered in totality, the set of items achieves three-dimensional alignment to the performance expectations assessed. Note that while each performance expectation combines specific aspects of each of the dimensions, additional aspects and/or dimensions may be leveraged by the student and/or the test developer. In addition, Delaware has differentiated between two types of item clusters. Integrated item clusters require extended amounts of time, allowing students to more fully demonstrate their three-dimensional learning by solving problems and designing solutions. Regular item clusters on the other hand require less time and afford more limited opportunities for students to demonstrate three-dimensional learning. The ITA includes both types of item clusters. The EoU assessments are made up entirely of integrated item clusters.

The ITA and EoU assessments also differ in depth and breadth. The EoU assessments are meant to provide direct feedback on three-dimensional student learning in relation to the standards taught in a specific instructional unit. That is, each unit is aligned to a specific set of PEs and each EoU assessment is aligned to the set of PEs (and the SEPs, DCIs, and CCCs that define these PEs). Students receive direct, rubric-based feedback for reflection and instructional/learning modification purposes after EoU assessments. The ITAs are meant to provide information on how well students can integrate, transfer, and apply their three-dimensional learning to novel phenomena that span those encountered during instruction over the course of the academic year. Following the ITA assessment, students receive a single, generalized proficiency score as a descriptor of their science proficiency.

Because what and how we choose to assess inevitably influences instruction, Delaware has chosen to use the MTAGS guide to monitor cognitive load inventories among item banks for all three assessment types. The overarching goal of the NGSS is for students to engage in science performances at the intersection of the three dimensions (Moulding, Bybee, & Paulson, 2015). Students who use crosscutting concepts to determine which science and engineering practices will help them best investigate, explain, or argue a claim related to a scientific phenomenon using appropriate disciplinary core ideas are DOING science. In classroom-embedded assessment settings, where students are involved with hands-on performance tasks, there are rich opportunities to offer prompts genuinely engaging students in DOING science. That opportunity is greatly decreased in both the EoU and large-scale summative (ITA) assessments. The obligation for states to produce valid and reliable assessments that result in predictable outcomes for large-scale assessments reduces the opportunity for the ambiguity that arises in novel problem solving. This does not mean, however, that the ability does not exist or should not be attempted for these assessments.

CONCLUSION

Well-developed two- and three-dimensional items that elicit student recognition of a clearly demonstrated, though unnamed, crosscutting concept within a stimulus can set the stage for student initiation of appropriate science and engineering practices and core ideas toward the solution of a problem. This is an example of DOING science. Scaffolding, such as identifying where to locate data or information and asking for the use of a specific practice, if removed from the item, leaves room for student autonomy while still limiting the parameters of a correct response. Under such circumstances, item writers will have developed "doing" science items, at two and three dimensions. While they are difficult to develop and often suffer during psychometric data analysis due to high difficulty measures, student mastery of these types of items is the goal of NGSS instruction, and therefore must be the goal for NGSS assessment.

In terms of the NGSS, the science and engineering practices, crosscutting concepts, and disciplinary core ideas interrelate within the context of scientific phenomena. The level of autonomy with which a student can identify and utilize appropriate skills and knowledge to interact with a phenomenon indicates a measure between actual cognitive development and potential development (Vygotsky & Cole, 1978). The amount of scaffolding or assistance provided by the question in combination with the number of NGSS dimensions that require activation for completion of the task provide a full picture of cognitive load upon which a student is focused during the assessment process. While conventional cognitive complexity models for large-scale assessment have been challenged by the expectations inherent in the NGSS, the MTAGS approach offers a more complete representation of the overarching cognitive load to working and long-term memory. Through a combined measure of element interactivity and degree of student autonomy in task response (scaffolding), the MTAGS approach is helpful in evaluating whether and if "assessment tasks that examine students' performance of scientific and engineering practices in the context of crosscutting concepts and disciplinary core ideas" (National Research Council, 2014, p. 44).

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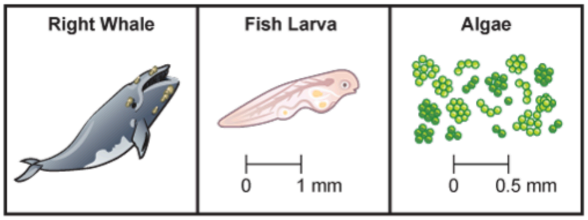
Delaware System of Student Assessments: Grade 5 Science Training Test
http://delaware.pearsonaccessnext.com/tutorial/sc-item-samplers/

Use the information in the tabs to answer the questions.

Tab 1—Ocean Ecosystem | Tab 2—Seasonal Changes | Tab 3—Algae | Tab 4—Fall Migration

A group of scientists is studying organisms in an ocean ecosystem. They show you three pictures of the organisms they see.

Figure 1: Organisms in an Ocean Ecosystem



- Right whales grow to be about 15 meters (m) long. That is about the length of a tractor-trailer.
- Fish larvae are young fish that just hatched from an egg. They are only a few millimeters (mm) in length, which is smaller than a sesame seed.
- Algae are plants that live in the ocean. They are smaller than the period at the end of this sentence.

The scientists watch the right whales eating the fish larvae. They also watch the tiny fish larvae eating algae. More fish larvae are found in areas of the ocean that have more algae.

Use the information in Tab 1 to help you answer this question.

Which **three** statements explain what happens when right whales eat the fish larvae as the whales swim in the ocean?

- A. Whales get matter they need in order to grow.
- B. Whales get energy they need in order to swim.
- C. Energy is transferred from the whales to the fish larvae as the whales eat.
- D. Energy and matter are transferred from the fish larvae to the whales as the whales eat.
- E. Matter is transferred from the water to the whales and the fish larvae as the whales eat.

Annotation: This multiple-select item asks students to select statements to construct an explanation (SEP) using the crosscutting concept of energy and matter and applying the core idea of organization for matter and energy flow in organisms (DCI). The item indicates, in specific instructions before the item, that the student is to use information from specific sources within the stimulus—which is a form of scaffolding in constructing explanations. The item does NOT tell the student what information to look for or what information is relevant to a correct response. This item is assigned a cognitive code of **GUIDED** with the **INTEGRATION of 3 DIMENSIONS**, or **GI3**.

Use the information in the tabs to answer the questions.

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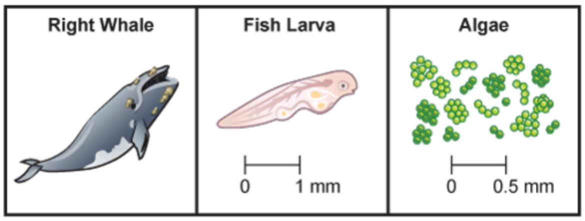

- Right whales grow to be about 15 meters (m) long. That is about the length of a tractor-trailer.
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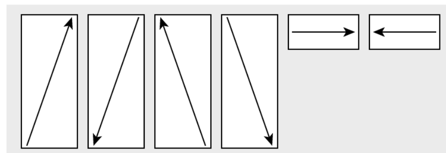
- Algae are plants that live in the ocean. They are smaller than the period at the end of this sentence.

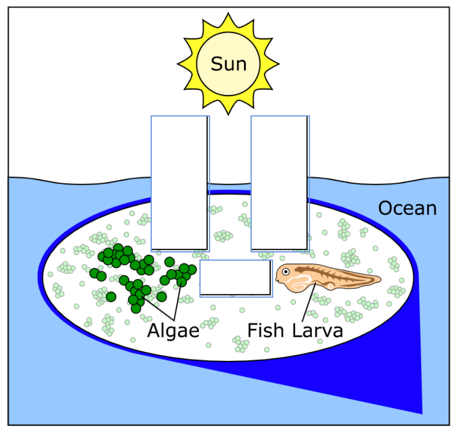
The scientists watch the right whales eating the fish larvae. They also watch the tiny fish larvae eating algae. More fish larvae are found in areas of the ocean that have more algae.

Use the information in Tab 1 to help you answer this question.

The scientists want you to model the flow of energy and matter through the ecosystem as fish larvae eat the algae. The scientists have a diagram showing the Sun, fish larvae, and algae.

Complete the diagram by dragging **two** arrows to show how energy flows among the Sun, the fish larvae, and the algae. The arrows should point in the directions that energy flows.





Annotation: This technology-enhanced item asks students to place arrows to construct a model (SEP) using the crosscutting concepts of energy and matter and applying the core idea of energy in chemical processes (DCI). The item indicates that the student is to use information from specific sources within the stimulus, tells students the direction in which arrows should point, and provides specific locations where arrows can be added to the model—which are forms of scaffolding in the use of model building. This item is assigned a cognitive code of **SCRIPTED** with the **INTEGRATION of 3 DIMENSIONS,** or **SI3.**

Use the information in the tabs to answer the questions.

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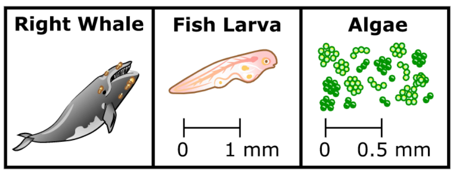
A group of scientists is studying organisms in an ocean ecosystem. They show you three pictures of the organisms they see.

Figure 1: Organisms in an Ocean Ecosystem



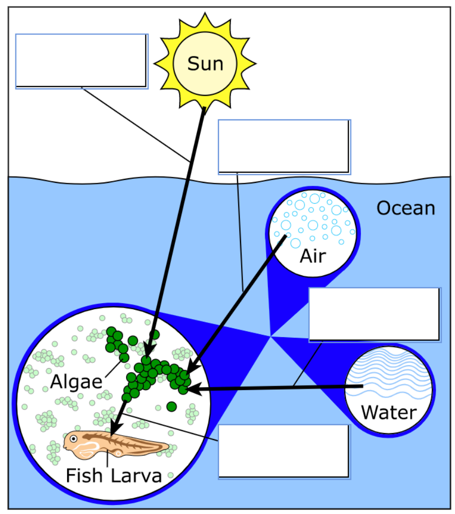
- Right whales grow to be about 15 meters (m) long. That is about the length of a tractor-trailer.
- Fish larvae are young fish that just hatched from an egg. They are only a few millimeters (mm) in length, which is smaller than a sesame seed.
- Algae are plants that live in the ocean. They are smaller than the period at the end of this sentence.

The scientists watch the right whales eating the fish larvae. They also watch the tiny fish larvae eating algae. More fish larvae are found in areas of the ocean that have more algae.

Use the information in Tab 1 to help you answer this question.

The scientists add both air and water to the diagram. They add arrows to show the directions in which matter and energy flow among the different parts in the diagram. Drag a label into **each** box to show if the arrow represents only the flow of energy, only the flow of matter, or the flow of both energy and matter.

Energy Only | Matter Only | Both Energy and Matter



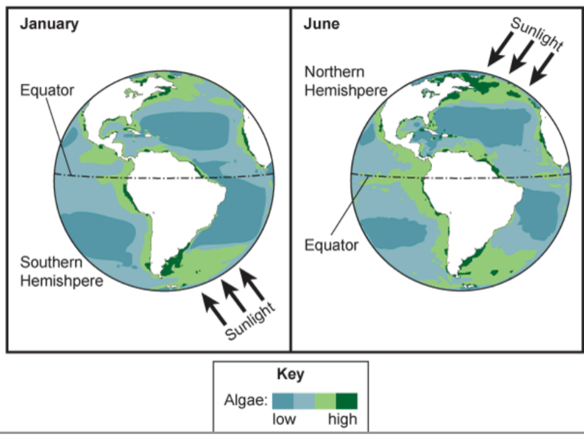
Annotation: This technology-enhanced item asks students to select and place labels to construct a model (SEP) using the crosscutting concepts of energy and matter and applying the core idea of flows of energy and matter in organisms (DCI). The item indicates that the student is to use information from specific sources within the stimulus and provides specific locations for placing the labels—which are forms of scaffolding in the use of model building. This item is assigned a cognitive code of **SCRIPTED** with the **INTEGRATION of 3 DIMENSIONS,** or **SI3.**

Use the information in the tabs to answer the questions.

Tab 1—Ocean Ecosystem | Tab 2—Seasonal Changes | Tab 3—Algae | Tab 4—Fall Migration

Figure 2 shows how the amount of algae in the ocean changes from January to June. The arrows show where sunlight is more direct during each season. Areas where the sunlight is more direct receive more sunlight. In January, the sunlight is more direct in the Southern Hemisphere. In June, the sunlight is more direct in the Northern Hemisphere.

Figure 2. Global Seasonal Changes in Energy and Matter



Use the information in Tab 2 to help you answer this question.

Which statement explains what **Figure 2** shows about algae?

- A. Algae move toward the Northern Hemisphere throughout the year.
- B. Algae move away from places where there is too much energy from the Sun.
- C. Algae grow in both hemispheres at the same rate throughout the year.
- D. Algae grow better in places where they have more energy from the Sun.

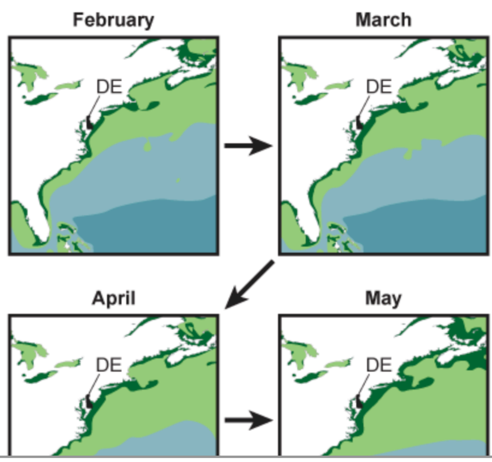
Annotation: This multiple-choice item asks students to analyze data (SEP) from a figure and select a statement to construct an explanation (SEP) using the crosscutting concepts of energy and matter and applying the core idea of energy in chemical processes (DCI). The item indicates, in specific instructions before and within the item, that the student is to use information from a specific source within the stimulus—which is a form of scaffolding in the use of data analysis and constructing an explanation. This item is assigned a cognitive code of **SCRIPTED** with the **INTEGRATION of 3 DIMENSIONS,** or **SI3.**

Use the information in the tabs to answer the questions.

Tab 1—Ocean Ecosystem | Tab 2—Seasonal Changes | Tab 3—Algae | Tab 4—Fall Migration

The scientists made the maps in **Figure 3** to show how the amount of algae in the North Atlantic Ocean changes from February to March to April and to May. The location of Delaware is shown on each map.

Figure 3. Algae in the North Atlantic Ocean



Use the information in Tab 3 to help you answer this question.

Part A

Based on the information in **Figure 3**, when will the scientists **most likely** find whales near Delaware?

- A. February
- B. March
- C. April
- D. May

Part B

Which **three** statements explain the answer to **Part A**?

- A. Less sunlight is available near Delaware during that month.
- B. More energy is available for algae near Delaware during that month.
- C. More matter is stored in algae near Delaware during that month.
- D. Less energy is stored in algae near Delaware during that month.
- E. More matter is available for whales near Delaware during that month.

Annotation: This two-part dependent item asks students to analyze data (SEP) from a figure and select a statement to construct an explanation (SEP) using the crosscutting concepts of energy and matter and applying the core idea of energy in chemical processes (DCI). The item indicates, in specific instructions before and within the item, that the student is to use information from a source within the stimulus—which is a form of scaffolding in the use of data and explanation building. The item does NOT tell the student what information to look for, how to organize the information, or what information is relevant to a correct response. This item is assigned a cognitive code of **GUIDED** with the **INTEGRATION of 3 DIMENSIONS**, or **GI3**.

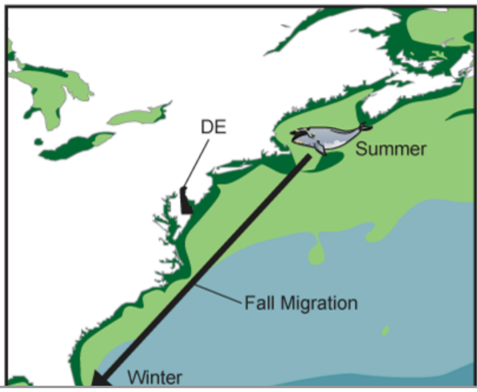
Use the information in the tabs to answer the questions.

Tab 1—Ocean Ecosystem | Tab 2—Seasonal Changes | Tab 3—Algae | Tab 4—Fall Migration

Right whales migrate along the coast as the amount of energy and matter in an area changes.

Figure 4 shows the location of the whales during the summer, their path as they migrate south in the fall, and their location during the winter. The whales are much bigger when they leave their summer location than when they first arrived in that location. Their bigger size helps the whales migrate during the fall.

Figure 4. Fall Migration



Use the information in Tab 3 and Tab 4 to help you answer this question.

Construct an explanation of why the whales are much bigger at the end of summer than when they first arrived. Support your explanation with evidence collected from **Figure 3** and **Figure 4**.

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Annotation: This extended-response item asks students to construct an explanation (SEP) using the crosscutting concepts of systems and system models (provided in the stimulus) and applying the core idea of interdependent relationships in ecosystems (DCI). In this case, the item indicates, both in specific instructions before the item and within the item, that the student is to use information from specific sources within the stimulus—which is a form of scaffolding in the use of model access and explanation building. The item does NOT tell the student what information to look for, how to organize the information, or what information is relevant to a correct response. In this case the item is assigned a cognitive code of **GUIDED** with the **INTEGRATION of 3 DIMENSIONS**, or **GI3**.

DELAWARE'S ASSESSMENT SYSTEM

Delaware is committed to a science assessment system that honors the principles of three-dimensional science learning while monitoring student readiness for challenging coursework in science and for college and career. The system reflects the state's mission for students to contextualize the crosscutting concepts across science core ideas and science and engineering practices.

The state's science assessment system offers three types of measures for understanding a student's progress in science. The summative assessments provide an evaluative measure in the benchmark years at the end of elementary school (grade 5), middle school (grade 8), and high school (biology). The results of the summative assessment are reported as a singular score of proficiency. The score from the summative assessment is intended to make a broad statement about lasting and pervasive knowledge and skills. More discrete information is collected throughout instruction by the other components of the state's assessment system. End-of-Unit Assessments are designed to provide rich data by measuring student abilities at a finer grain at intervals throughout the school year and across grades three through ten, while classroom assessments provide information throughout ongoing instruction. Other progress measures may include a student's grades, classroom exams, districtwide tests, and more.

The Next Generation Science Assessment System for Delaware learners is a comprehensive and balanced assessment system with three distinct parts:

- Embedded Classroom Assessments are developed by teachers to provide information on learning in real time in every grade from third grade through tenth grade. The assessments are primarily for instructional use and are therefore short and administered at the discretion of each teacher. The development of these has been supported by professional development.

- End-of-Unit Assessments, aligned to instructional units in every grade from third through tenth, are administered by teachers after the completion of each instructional unit. Each End-of-Unit Assessment is meant to provide information on student learning of the NGSS content in each unit for the purposes of instruction (e.g., to determine whether additional instruction on previously instructed topics is needed, or to use as a classroom assessment for grading purposes) and evaluation (e.g., to inform curriculum adoption, adaptation, and modification) at classroom, school, and district levels. End-of-Unit Assessments are developed by vendors working with DDOE staff and informed by educator reviews for classroom administration by teachers.

- The Integrative Transfer Assessment is administered to students in grade 5, grade 8, and high school biology. The Integrative Transfer Assessment is meant to capture students' learning of the content instructed during the entire year in each of the three grades in greater depth than the End-of-Unit Assessments. The Integrative Transfer Assessment requires students to apply their knowledge of science to grade-level-appropriate situations in order to solve unique, real-life problems. Integrative Transfer Assessments are developed by vendors working with DDOE staff and informed by educator committee reviews. They are administered through an online system in a secure testing environment and used for state accountability purposes.