Moving Next Generation Science Standards into Practice: A Middle School Ecology Unit and Teacher Professional Development Model

Barbara Nagle\textsuperscript{1}, John Howarth\textsuperscript{1}, James Short\textsuperscript{2}, Dora Kastel\textsuperscript{2}, Suzanne Wilson\textsuperscript{3}, Maia Willcox\textsuperscript{1}, Anna McPherson\textsuperscript{2}, Bianca Montrosse-Moorhead\textsuperscript{3}, Manisha Hariani\textsuperscript{1}, and Jay Holmes\textsuperscript{2}

Lawrence Hall of Science, University of California, Berkeley\textsuperscript{1}  
American Museum of Natural History\textsuperscript{2}  
University of Connecticut\textsuperscript{3}

Contact Barbara Nagle: bnagle@berkeley.edu  
Paper: sepuplhs.org/pdfs/NARST2016.pdf

This material is based upon work funded by the National Science Foundation under Grant # NSF DRL 1418235. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.
Moving Next Generation Science Standards into Practice

• Four Partners:
  • Lead and Professional Development: American Museum of Natural History (AMNH)
  • Curriculum: Lawrence Hall of Science
  • Research: University of Connecticut
  • Evaluation: WestEd
• Four-year project began September 2014
• First 18 months focused on developing and testing a curriculum unit and PD model
Project Overview

• Develop an NGSS-aligned middle school ecology curriculum unit and assessments
• Develop a professional development program to support teacher implementation
• Conduct:
  – Formative evaluation of the curriculum
  – Formative evaluation and research on the professional development
  – Development of and research on teacher measures
Disruptions in Ecosystems—Ecosystem Interactions, Energy, and Dynamics

- Based on a bundle of NGSS (Table 1) and related CCSS for ELA and Mathematics (Table 3)
  - MS-LS2: Ecosystems: Interactions, Energy, and Dynamics
  - MS-ESS3: Earth and Human Activity
  - MS-PS1: Matter & Its Interactions
- Uses the BSCS 5E Instructional Model (Bybee et al, 2006; Bybee, 2013)
  - Engage, Explore, Explain, Elaborate, Evaluate
Disruptions in Ecosystems—Ecosystem Interactions, Energy, and Dynamics

- Educative elements for teachers related to S-CK and S-PCK
- Embedded authentic assessments of 3D learning
- Supports for
  - Literacy & CC-ELA
  - Diverse learners
  - Development of science practices
Curriculum Development and Design

Backward design approach
– Define learning goals
– Draft assessments
– Develop learning activities

Supported by use of the *Five Tools and Processes for NGSS* (developed by AMNH, BSCS, WestEd)

**Types of Interactions**

Predator-prey interactions, competition, and symbiosis are all interactions between living factors. A *predator-prey* interaction involves a feeding relationship between two animals. The *predator* is the animal that kills and consumes another animal, called the *prey*. In the photo below the bear is the predator and the fish is the prey.
Curriculum evaluation

- Feedback from 2015–2016 field test by 25 NYC teachers
  - Surveys by activity, chapter, unit
  - Focus groups
  - Feedback during final PD day
  - Student work samples
- Expert panel meeting and written review
  - NGSS and 3D learning
  - 5E model
  - Educative aspects of the materials
  - Support for English language learners/diverse learners
  - Usability
  - Professional development
- The first of three iterative cycles of feedback and revision
Assessments

Assessment specifications were developed through the use of the Five Tools

Three-dimensional assessments

• Embedded in learning activities
• In a culminating Evaluate activity
• In end-of-chapter tests
Coherence

• Instructional materials are organized through a conceptual storyline.
• The storyline is a connection of scientific ideas (DCIs, and CCCs) that are investigated by use of scientific and engineering practices and nested in a conceptual flow that builds across time.
• In a coherent storyline, students engage in making sense of phenomena or designing solutions to problems.
Disruptions in Ecosystems

Ecosystem Interactions, Energy, & Dynamics

CHAPTER 1: Wolves in Yellowstone
CHAPTER 2: Ecosystem Models
CHAPTER 3: Interactions between Populations & Resources
CHAPTER 4: Zebra Mussels
CHAPTER 5: Designing Solutions
Key educative elements

(Davis and Krajcik, 2005)

Field test 2015–2016
• Design Heuristic 2: Support for using scientific instructional representations
• Design Heuristic 4: Support for analyzing and interpreting data
• Design Heuristic 7: Support for making explanations based on evidence

Field test 2016–2017
• Design Heuristic 9: Support for development of teachers’ S-CK
Activity 1.6

Elaborate: Analyzing Patterns in Ecosystems

Organisms in an ecosystem interact with both biotic and abiotic factors. For example, squirrels living in and near a city park might be affected by biotic factors such as the availability of nuts, seeds, and berries, people who feed them, and raccoons and hawks that might eat them. Abiotic factors such as water shortages, mild or extreme weather, expansion of the parkland, or construction of homes in the area might also affect the population size.

Guiding Question
How do biotic and abiotic interactions affect populations?

Disciplinary Core Ideas
Interactions in ecosystems

Science Practices
Explanation

Crosscutting Concepts
Patterns
Constructing Science Explanations

5. With your group, discuss what you think might happen to the organisms on each graph over time.

6. Your teacher will assign your group to focus on one of the scenarios. Explain why you think the graph you selected matches the scenario.

7. Using the Explanation Tool, construct a scientific explanation about the patterns of interactions in your scenario. Use the list below to guide you as you use the Explanation Tool.

- **Question**: Record the question "Which graph best represents the patterns of interactions described in your scenario?"

- **Initial Thinking**: Record your thinking from Step 5 for your scenario.

- **Evidence**: Examine the data in the graph(s) that you matched with your scenario. What patterns do you notice? Describe these patterns to use them as evidence.

- **Claim**: Based on the evidence, state a claim about the patterns of interactions in your scenario. Does your claim agree with your initial thinking?

- **Science Concepts**: Apply the science concepts you have already learned to explain how the evidence supports your claim.

- **Scientific Reasoning**: Use the template provided on the Explanation Tool to describe the scientific reasoning that explains how the evidence and science concepts lead to your claim.
Learning Scaffold for Constructing Explanations

<table>
<thead>
<tr>
<th>Question</th>
<th>What is the scientific question you are investigating?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background Knowledge</td>
<td>What do you already know related to your question?</td>
</tr>
<tr>
<td>Initial Thoughts</td>
<td>Based on what you already know, what do you think the data will show?</td>
</tr>
<tr>
<td>Evidence</td>
<td>What are the science observations or data that address your question?</td>
</tr>
<tr>
<td>Claim</td>
<td>What claim can you make based on the evidence?</td>
</tr>
<tr>
<td>Science Concepts</td>
<td>What science concepts are connected to the evidence and help explain the claim?</td>
</tr>
</tbody>
</table>

Does your claim agree with your initial thinking? Why or why not?

Scientific Reasoning
What relevant evidence led you to your claim? How do the science concepts relate to the evidence?

The evidence that led to my claim is (evidence). The concepts that relate to the evidence and support my claim are (science concepts). These concepts support my claim because _______________________.

Construct a Scientific Explanation
Using the information in the boxes you have completed, write a scientific explanation that includes:
- The scientific question
- Your claim
- Relevant evidence that supports your claim
- Science concepts that support the evidence
- Scientific reasoning that links the evidence and science concepts to the claim

Scientific Explanation

© 2015 American Museum of Natural History. All rights reserved.
### Anticipation Guide: Energy in Ecosystems

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1. Light from the Sun is one of many energy sources for plants. Other energy sources include soil, water, and air.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Plants need only soil, water, and sunlight to make their own food.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. If all the plants in the Yellowstone ecosystem died from a disease, the coyotes in the area would always survive because they could eat rabbits.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Heat given off by animals can be used by plants to make food.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. In a food chain, most of the energy stored in organisms is lost to the non-living environment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Energy flows in one direction within ecosystems, from plants to animals.</td>
</tr>
</tbody>
</table>
Findings

Strengths of the curriculum

• Support for three-dimensional learning
• Use of scaffolds for teachers and students
• Literacy strategies
• Selected educative elements
• Student engagement
• Teachers’ understanding of ecosystems and pedagogy enhanced
Findings

Key areas for revision of curriculum

• Bring the NGSS dimensions more into balance and add more support for teachers
• Increase the supports for reading, writing, and classroom discourse
• Enhance the educative elements and improve format of the Teacher’s Guide (challenging)
• Introduce the explanation and argumentation tools more gradually, decrease formal writing
• Reduce the length of the unit
• Revise the early chapters of the unit to better reflect the 5E model
Findings

PD Strengths
• Developed understanding of the 5E’s
• Developed understanding of strategies for teaching ecology
• Developed understanding of the complexity of ecology

PD Revision
• Provide more/better support for explanation and argumentation practices.
• Spread more frequent PD sessions over a longer period of time
Next steps

• Revise curriculum to further bring out 3-dimensional learning and support teachers and students

• Field test again 2016–2017
Acknowledgements

Katherine Stiles, WestEd

NSF

This material is based upon work funded by the National Science Foundation under Grant # NSF DRL 1418235. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.
Contact Barbara Nagle: bnagle@berkeley.edu
Paper: sepuplhs.org/pdfs/NARST2016.pdf