Developing the Practice of Modeling in an NGSS-aligned Educative Middle School Ecosystems Instructional Materials Unit

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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 NGSS into Practice

• Four Partners:
  – Lead and PD: AMNH
  – Instructional Materials: Lawrence Hall of Science
  – Research: University of Connecticut
  – Evaluation: WestEd

• Four-year project began September 2014
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
## Project Timeline

<table>
<thead>
<tr>
<th>Timeframe</th>
<th>Milestones</th>
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</thead>
</table>
| September 2014 – July 2015 | • Develop first field test instructional materials  
                           | • Develop first field test PD model                                      |
| August 2015 – February 2016 | • 25 NYC teachers field test  
                               | • Expert panel review                                                     |
| March 2016 – July 2016   | • Revise materials and PD model for second field test                      |
| August 2016 – February 2017 | • 25 NYC teachers field test  
                          | • Second expert review                                                   |
| March 2017 – July 2017   | • Revise materials and PD model for final field test                      |
| August 2017 – February 2018 | • 25 NYC teachers field test  
                           | • Further review if needed                                                |
| March 2018 – August 2018 | • Final revisions to materials and PD model                               |
**Disruptions in Ecosystems—Ecosystem Interactions, Energy, and Dynamics**

- Based on a bundle of NGSS and related CCSS for ELA and Mathematics
  - 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)

In the photo below the bear is the predator and the fish is the prey.
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.
Context
Developing the Modeling Practice

• Focus of Chapter 2: Ecosystem Models
• Content: flow of energy and cycling of matter
• Six activities
• Context: Yellowstone National Park ecosystem
• Particular attention to common misconceptions around energy and matter
# Chapter 2: Ecosystem Models

## First Field Test

<table>
<thead>
<tr>
<th>Activity</th>
<th>5E Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Living Model of an Ecosystem</td>
<td>Engage/Explore</td>
<td>Analyze statements on energy and matter; set up ecosystem model</td>
</tr>
<tr>
<td>Energy Flow in Ecosystems</td>
<td>Explain</td>
<td>Reading with anticipation guide</td>
</tr>
<tr>
<td>Energy Pyramid</td>
<td>Explore/Explain</td>
<td>Develop a model of an energy pyramid</td>
</tr>
<tr>
<td>Matter in Ecosystems</td>
<td>Explore/Explain</td>
<td>Ecosystem model exploration (Act 1); Reading</td>
</tr>
<tr>
<td>Fire in Yellowstone</td>
<td>Elaborate</td>
<td>Card sort with succession after fire and in a pond, with captions</td>
</tr>
<tr>
<td>Modeling Energy Flow and Matter Cycling in an Ecosystem</td>
<td>Evaluate</td>
<td>Develop a 3-d model that shows food web, cycling of matter, and flow of energy</td>
</tr>
</tbody>
</table>
Curriculum Evaluation – Year 1

• Feedback from 25 NYC field test teachers
  — Surveys by activity, chapter, unit
  — Focus groups
  — Feedback during final PD day
  — Student work samples

• Expert panel meeting and written review
Findings – Year 1

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 – Year 1

Key areas for overall revision
• Bring the 3 dimensions more into balance and add more teacher support
• Increase the supports for reading, writing, and classroom discourse
• Enhance the educative elements
• 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 – Year 1

Chapter 2 Specific Revisions -

• Simplify and reduce overall number of models
• Better reflect 5E model
• Prevent student misconceptions by having students create initial model which is revised throughout the chapter
# Chapter 2: Ecosystem Models

## Second Field Test

<table>
<thead>
<tr>
<th>Activity</th>
<th>5E Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosystem Changes</td>
<td>Engage</td>
<td>Analyze &amp; discuss ecosystems &amp; ecosystem disruptions; composting</td>
</tr>
<tr>
<td>Life and Death in an Ecosystem</td>
<td>Explore</td>
<td>Develop Yellowstone ecosystem model (YEM); analyze model of change in ecosystem over time</td>
</tr>
<tr>
<td>Matter in Ecosystems</td>
<td>Explain</td>
<td>Analyze scientific findings about matter in ecosystems; develop a model for cycling of matter</td>
</tr>
<tr>
<td>Energy Flow in Ecosystems</td>
<td>Explain</td>
<td>Add flow of energy to YEM; read about photosynthesis; model revision</td>
</tr>
<tr>
<td>Energy Tracking</td>
<td>Elaborate</td>
<td>Analyze existing models re energy; develop energy pyramid model; YEM revision</td>
</tr>
<tr>
<td>Modeling Energy Flow and Matter Cycling in an Ecosystem</td>
<td>Evaluate</td>
<td>Develop a 3-d model that shows food web, cycling of matter, and flow of energy</td>
</tr>
</tbody>
</table>
Curriculum Evaluation – Year 2

• Feedback from 25 NYC field test teachers
  – Surveys by chapter and unit
  – Focus groups
  – Feedback during final PD day
  – Student work samples
• Expert review
Findings – Year 2

Feedback on Changes to Chapter 2

• More successful in developing deep understanding of matter and energy

• Teachers have better understanding of matter and energy

• Still a difficult topic!
Teacher Feedback

I learned how important it is to incorporate models in a curriculum. I learned that most students struggle to understand what is matter. I learned a great way to teach how matter and energy connect to one another. Usually students learn what is matter and what is energy but they do not connect the two. I feel this chapter really addressed that. (Stiles, 2017)
Findings – Year 2

Chapter 2 Specific Revisions -

• Deepening teacher support

• Simplifying material that students are analyzing (e.g. fewer scientific findings)

• Increasing support for analyzing materials (e.g. graphic organizer to guide analysis)
Overall Conclusions

• Fewer number of models
• Some existing model analysis helps
• Allow students to develop and revise their models over the course of several activities
Next steps

- Finish third round of revisions
- Field test again 2017 – 2018
Acknowledgements

Manisha Hariani & John Howarth, LHS
Dora Kastel & Anna MacPherson, AMNH
Bianca Montrosse-Moorhead & Suzanne Wilson, UCONN
Katherine Stiles, WestEd

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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.
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