Learning Progressions: 
It’s All About Fused Knowledge 
(Content + Practices + Crosscutting Concepts)

Nancy Butler Songer
Professor of Science Education and Learning Technologies
Director, Center for Essential Science
The University of Michigan

National Science Foundation DRK-12 PI Meeting 6.15.12
NGSS and Fused Knowledge

“The standards are written as student performance expectations...These statements each incorporate a practice, a disciplinary core idea, and a crosscutting concept. The performance expectations are the assessable components of the NGSS architecture.” (Achieve draft, May 2012)
How Do We Use Learning Progressions?

• 1. Framing scientific knowledge and goals
  - e.g., Identify what knowledge is important
2008: Three Year Content Learning Progression in Ecology and Biodiversity

**Classification Content Strand**
- Organisms interact by eating each other
- Organisms are grouped based on their structures they have in common, like a classification ladder

**Ecology Content Strand**
- E14. Humans are part of one of the food chains. They depend on food chains for food, shelter, and clothing.
- E15. The studying of animals and plants is called ecology. Ecology helps explain how organisms interact with each other and their environment.
- E16. The study of animals and their behavior is called behaviorism. Behaviorism helps explain how organisms interact with each other and their environment.
- E17. The study of plants and their behavior is called botany. Botany helps explain how organisms interact with each other and their environment.

**Biodiversity Content Strand**
- B11. Human activity and other factors affect biodiversity of ecosystems (producers, species, changing habitat), qualities of food web modifications.
- B12. Biodiversity helps buffer ecosystems against change and provides other benefits to humans. Biodiversity can be used as a way to measure the health of an ecosystem.
- B13. Natural changes in ecosystems (succession, natural disasters, affect biodiversity and species composition.
- B14. Ecosystems change naturally over time (succession). It is a natural way for species to interact and compete for resources. Plants may compete for light, water, or nutrients, and animals may compete for food or shelter.
- B15. Organisms change over time, and biodiversity patterns reflect those changes.

**Upper Anchor**

**Lower Anchor**

**5th Grade**
- E18. All area has high biodiversity if it has low human activity (mining, deforestation, and pollution).
- E19. Biodiversity is measured using the number and variety of different organisms in a particular area (ecology, arthropods, or plants), species, or habitat (desert, forest, or wetland). Biodiversity can be measured using the number of different organisms in an area.
- E20. The study of animals and their behavior is called behavior. Behavior helps explain how organisms interact with each other and their environment.
- E21. The study of plants and their behavior is called botany. Botany helps explain how organisms interact with each other and their environment.

**6th Grade**
- E22. Organisms are grouped based on their structures they have in common, like a classification ladder.
Focal Knowledge We Care About = Knowledge That Fuses **Content** + **Practices**

- **Content**: Because many animals rely on each other, a change in the number of one species can affect different members of the web.

- **Science Practice Explanations**: Students build a complete scientific explanation consisting of a claim, two pieces of evidence and reasoning.

- **Fused C+P CC**: Students construct scientific explanations to address the question, How have recent changes in the Detroit River affected yellow perch populations?
## Learning Progression, Climate Change Impacts

### Content Highlighted

**Cluster 1: Biotic Interactions**
- **1a.** Collect data to show how things in the school yard serve as a species’ habitat.
- **1b.** Analyze data to show where a focal species lives.
- **1c.** Use representations in a form of a food web to address the question: what does my species eat and what eats my species?
- **1d.** Analyze data in the form of two species distributions to compare the locations of predator-prey habitats.
- **1e.** Construct an explanation to address the scientific question: why doesn’t my focal species distribution completely overlap with the distribution of its prey?

**Cluster 2: Abiotic Factors**
- **2a.** Analyze data of species distribution and abiotic conditions (temperature and precipitation), to identify patterns in abiotic conditions that influence where a focal species lives.
- **2b.** Apply mathematical routines (averages) to historic and current temperatures and create representations to compare historic and current average temperatures (climate).
- **2c.** Analyze data to identify patterns of average temperature rates over the last 100 years?

**Cluster 3: Natural Processes**
- **3a.** Create a representation (Carbon Cycle) of the movement of Greenhouse gases through the environmental system.
- **3b.** Create a representation to describe the greenhouse effect.
- **3c.** Construct an explanation to address the scientific question, is there a relationship between carbon dioxide and changing climate?

**Cluster 4: Predictions**
- **4a.** Use a representation (Carbon Card Game) to tell a story about human activities and their associated carbon production.
- **4b.** Construct several justified predictions of how human activities influence the rate of future carbon dioxide production and temperature increases using knowledge of the carbon cycle and human activities.

**Cluster 5: Species Predicted Futures**
- **5a.** Use a representation of a prediction to analyze the future impact of climate change on the Pike and on a focal species’ distribution.
- **5b.** Construct a justified prediction using data to address the scientific question, does Future 1 predict affects on predator-prey interactions for my focal species?

### Practices Highlighted

**Super Synthesis**
- **Super Synthesis**

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**SSa.** Create representations to document how human activity in your community has positive or negative affects on climate change.
Learning Goals Highlighted by Content

3c. **Construct an explanation** to address the scientific question, is there a relationship between carbon dioxide and changing climate?

3b. **Create a representation** to describe the greenhouse effect.

3a. **Create a representation** (Carbon Cycle) of the movement of Greenhouse gases through the environmental system.

- **Abiotic**
- **Biotic**
- **Fusion: Abiotic + Biotic**
Learning Goals Highlighted by Science Practices

3c. Construct an explanation to address the scientific question, is there a relationship between carbon dioxide and changing climate?

3b. Create a representation to describe the greenhouse effect.

3a. Create a representation (Carbon Cycle) of the movement of Greenhouse gases through the environmental system.
How Do We Use Learning Progressions?

• 2. Formative and summative assessment
  - e.g., Identify what knowledge to assess
Assessment Emphasizing Fused Knowledge

Beth wrote this explanation below to answer the scientific question, **Is there evidence that climate change will affect where plants and animals can live in the future?**

A. Is there anything you would change about Beth’s explanation?
   “Yes.”

B. If you would change something, what would you write instead?
   “Instead of talking about what she saw on the maps I would use real life evidence. Like the example about polar bears and ice caps.”
   “Her reasoning and evidence isn’t legit. It only states the warmth which isn’t enough to say climate change will affect where plants and animals can live.”
How Do We Use Learning Progressions?

• 3. Scaffolding students’ practices fused to core science content
  - e.g., Provide guidance on how to guide learning through “the messy middle” towards upper anchor
5c. Construct a representation of an explanation to address the scientific question, "what does Future 1 look like for my species?"  

5b. Construct a justified prediction using data to address the scientific question, "does Future 1 predict effects on predator-prey interactions for my focal species?"  

5a. Use a representation of a prediction to analyze the future impact of climate change on the northern pike (the fish species) and on a focal species’ distribution.
Future Scenarios from (IPCC) = COMPLEX

Future climate change depends on future greenhouse gas emissions. Future greenhouse gas emissions depend on socio-economic choices.
Prediction-Making using Models of Simplified Climate Change Scenarios for Middle/High Schoolers

Future climate change depends on future greenhouse gas emissions.
Future greenhouse gas emissions depend on socio-economic choices.

<table>
<thead>
<tr>
<th>Population growth rate</th>
<th>Energy use per person</th>
<th>Proportion clean energy</th>
<th>Total CO₂ emissions by 2100 (gigatons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Future 1</td>
<td>Fast</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Future 2</td>
<td>Slow</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Future 3</td>
<td>Slow</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

School of Education, University of Michigan
Simplified Modeled Predictions

Is there evidence that climate change will impact the distribution of my species, Red Squirrel?

Focal Species Current and Future Distributions

- red squirrel (Tamiasciurus hudsonicus)
- Future 1 OFF
- Future 2 OFF
- Future 3 OFF
Red Squirrel: Future 1
Red Squirrel: Future 2

Focal Species Current and Future Distributions

Species...  
red squirrel (Tamiasciurus hudsonicus)  

Future 1  
OFF

Future 2  
ON

Future 3  
OFF
Red Squirrel: Future 3

Focal Species Current and Future Distributions

Species...
red squirrel (Tamiasciurus hudsonicus)  ON OFF

Future 1  OFF
Future 2  OFF
Future 3  ON
Guided Reflection in Constructing Explanations to address question, Is there evidence that climate change will impact the distribution of my focal species?

My Scientific Explanation

**My claim is:**

**My reasoning is:**

A statement that describes how particular evidence supports a scientific claim. For example, you can use scientific definitions, scientific concepts or ideas to explain why you choose the evidence you did.

**Evidence**

Evidence are observations, data, or information that helps you answer the scientific question.

**Hint**

What is the difference between weather and climate?

What kind of evidence is used to describe climate?
Conclusions

• Largest gap in current research on learning progressions is in the area of assessment design and assessment evaluation

• Second priority: Discussions about use of LPs and representing the knowledge we (and NGSS) care about:

• Fused content + practices + crosscutting concepts