Using Learning Progression Frameworks to Inform Instruction in Environmental Science: Teachers’ Efforts to Move Their Students Up Levels

Nissa Rae Yestness, Tobias Irish, Julie A. Bianchini, Jiwon Kim, LaTisha M. Hammond, Stacey Carpenter, Sylvia D. Parker, Katherine J. Nilsen, and Alan R. Berkowitz

NARST Annual Meeting 2015
Introduction to Pathways

Pathways was a five-year environmental science research and professional development (PD) effort.

• Distributed across four regions

• Targeted middle school and high school science teachers.

• Focused on promoting environmental science literacy through (a) developing learning progressions, (b) developing curriculum materials and assessments, and (c) supporting teachers.
Pathways Case Study
Research Questions

1. How did teachers implement two focal strategies of formative assessment and principle- and/or evidence-based reasoning in their classrooms?

2. How did the curricular materials support (or not) teachers’ use of the focal strategy of principle- and/or evidence-based reasoning?
Pathways Case Study Conceptual Framework

- Learning Progressions and Aligned Strategies
- Attending to Students’ Ideas
  (Furtak, 2012; Harlow, 2010)
- The Centrality of Discourse in Teaching and Learning
  (Bunch, 2013; Lee, Quinn, & Valdes, 2013; Lemke, 1990)
## Pathways LP Levels

<table>
<thead>
<tr>
<th>Learning Progression Levels</th>
</tr>
</thead>
</table>
| **IV – Scientific Model-Based Accounts**  
Students apply fundamental principles, such as conservation of energy or genetic continuity, to phenomena at multiple scales in space and time (generally consistent with current national standards). |
| **III – School Science Accounts**  
Students show awareness of important scientific principles and of models at smaller and larger scales, but they have difficulty connecting accounts at different scales and applying principles consistently. |
| **II – Force-Dynamic Accounts with Hidden Mechanisms**  
Students continue to focus on actors, enablers, and natural tendencies of inanimate materials. However, they add detail and complexity, especially at larger and smaller scales. |
| **I – Simple Force-Dynamic Accounts**  
Students focus on actors, enablers, and natural tendencies of inanimate materials, using relatively short time frames and macroscopic scale phenomena. |
## Pathways Teaching Strategies Aligned to Learning Progressions (LPTTs)

<table>
<thead>
<tr>
<th>LPTS 1</th>
<th>Big Ideas</th>
<th>Focus on big ideas in the field of study, supported by LP.</th>
</tr>
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<tbody>
<tr>
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<td>Citizen Practices</td>
<td>Support engagement in science-based citizenship decision-making practices.</td>
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Pathways PD at Four Sites Across US

- PD team included scientists, experienced teachers, science educators, postdoctoral fellows, and graduate students.

- Annual summer institutes and periodic follow-up meetings during the academic year were run.

- Content of PD activities:
  - Discussed learning progressions.
  - Engaged teachers in sample activities and authentic learning experiences.
  - Explored students’ responses to assessments.
  - Provided support during implementation.

- PD teams tracked teachers’ participation in the PD and used their feedback to improve the PD and TEs.
## Pathways Teaching Experiments

<table>
<thead>
<tr>
<th>Project Themes</th>
<th>Teaching Experiments (TEs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Biodiversity</td>
</tr>
<tr>
<td><strong>Learning Progressions</strong></td>
<td>Focus on Student Thinking</td>
</tr>
<tr>
<td></td>
<td>Biodiversity Assessments</td>
</tr>
<tr>
<td><strong>Main Investigation</strong></td>
<td>Leaf Pack Organisms</td>
</tr>
<tr>
<td><strong>Citizenship</strong></td>
<td>Evaluating socio-scientific arguments</td>
</tr>
<tr>
<td><strong>Culture and Place</strong></td>
<td>Site- and Context-Specific</td>
</tr>
</tbody>
</table>
## Pathways Case Study
### Teacher Participants

<table>
<thead>
<tr>
<th></th>
<th>West Coast</th>
<th></th>
<th></th>
<th>Mountain</th>
<th></th>
<th></th>
<th>Great Lakes</th>
<th></th>
<th></th>
<th>East Coast</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher</strong></td>
<td><strong>Grade</strong></td>
<td><strong>TE</strong></td>
<td></td>
<td><strong>Teacher</strong></td>
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</tr>
<tr>
<td>Ms. E</td>
<td>MS</td>
<td>Carbon</td>
<td></td>
<td>Ms. S</td>
<td>MS</td>
<td>Carbon</td>
<td>Mr. G</td>
<td>HS</td>
<td>Carbon</td>
<td>Mr. A</td>
<td>HS</td>
<td>Carbon</td>
</tr>
<tr>
<td>Mr. K</td>
<td>MS</td>
<td>Water</td>
<td></td>
<td>Mr. J</td>
<td>MS</td>
<td>Water</td>
<td>Mr. D</td>
<td>MS</td>
<td>Water</td>
<td>Ms. P</td>
<td>HS</td>
<td>Water</td>
</tr>
<tr>
<td>Ms. L</td>
<td>MS</td>
<td>Water</td>
<td></td>
<td>Ms. V</td>
<td>HS</td>
<td>Water</td>
<td>Ms. F</td>
<td>HS</td>
<td>Biodiversity</td>
<td>Mr. B</td>
<td>HS</td>
<td>Biodiversity</td>
</tr>
<tr>
<td>Ms. Z</td>
<td>MS</td>
<td>Biodiversity</td>
<td></td>
<td>Ms. T</td>
<td>MS</td>
<td>Biodiversity</td>
<td>Ms. R</td>
<td>HS</td>
<td>Biodiversity</td>
<td>Ms. M</td>
<td>HS</td>
<td>Biodiversity</td>
</tr>
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Mr. J argued that engagement in reasoning was important in moving students up higher levels of a progression (LPTS 6).

I think on the lower levels of learning progressions, students need to be engaged in the learning. They need to be doing something where they’re seeing it, experiencing it. . . . I think when you get up to the upper levels, it’s more of setting the stage for asking the question, “Why? Why? Why? Why?” And then have those students making a claim and really critiquing – challenging them to provide evidence to support that claim. I think in school we play school and you say, “Why?” “Because that’s the way that nature works, because there’s heat added.” Well, then keep asking, “Why? Well, why does – what role does heat have into that? What drives that?” (Interview 1)
Pathways Case Study Research Questions

1. How did teachers implement two focal strategies of formative assessment and principle- and/or evidence-based reasoning in their classrooms?

2. How did the curricular materials support (or not) teachers’ use of the focal strategy of principle- and/or evidence-based reasoning?
Data Collection

Data were collected during the 2012-2013 academic year.

(1) From case study teachers:
   – Teacher Interviews (4 per teacher)
   – Teacher Written Reflections (2 per teacher)
   – Teacher Feedback Form on TE (1 per teacher)
   – Teacher End-of-Year Survey (1 per teacher)
   – Teacher Content Test (pre and post for TE per teacher)
   – Video records of 5 lessons

(2) From students in video recorded class:
   – Student Written Work (many per student)
   – Student Survey (1 per student)
   – Student Focus Group (1 per class)
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(2) From students in video recorded class:
   - Student Written Work (many per student)
   - Student Survey (1 per student)
   - Student Focus Group (1 per class)
To answer question 1:  
How did teachers implement these focal strategies in their classrooms?

- Video records of 5 days of classroom instruction
- Segments, teacher-student discussions, and productive discussions (Michaels & O’Conner, 2012)
# Data Analysis: Learning Progression Teaching Strategies

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Data Analysis: Nature of Implementation

Formative Assessment:

- **Emergent**: teachers eliciting student ideas, but not discussing or addressing them

- **Transitional**: teachers beginning to use student ideas in discussions

- **Sophisticated**: teachers moving beyond *eliciting* student ideas to *engaging* students with these ideas
Data Analysis: Nature of Implementation

Principle- and Evidence-Based Reasoning:

• **Emergent**: teachers using something like a process tool to engage students in principle- and/or evidence-based reasoning, but not making this explicit to the students; teacher doing most of reasoning

• **Transitional**: teachers focusing on asking probing questions, such as ‘why do you think that?’ with some of the reasoning still provided by the teacher

• **Sophisticated**: teachers explicitly asking students for reasoning based on principles and/or evidence through class discussion; students doing most of reasoning
Findings

1. How did teachers implement the two focal strategies in their classrooms?

2. How did the curricular materials support (or not) teachers’ use of the focal strategy of principle- and/or evidence-based reasoning?
# Findings: Instances of Formative Assessment

<table>
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<th>Water (3 of 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms. E</td>
<td>5 (2)</td>
<td>Ms. P</td>
</tr>
<tr>
<td>Mr. G</td>
<td>3 (3)</td>
<td>Ms. L</td>
</tr>
<tr>
<td>Ms. S</td>
<td>2 (1)</td>
<td>Mr. J</td>
</tr>
<tr>
<td>Mr. A</td>
<td>1 (0)</td>
<td></td>
</tr>
</tbody>
</table>
Findings:
Nature of Formative Assessments

- Carbon
- Water
- Biodiversity

- Sophisticated
- Transitional
- Emergent
Findings:
Instances of Principle- and/or Evidence-Based Reasoning

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Carbon (4 of 4)</th>
<th>Water (6 of 6)</th>
<th>Biodiversity (2 of 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms. E</td>
<td>10 (3)</td>
<td>Ms. J</td>
<td>7 (4)</td>
</tr>
<tr>
<td>Mr. G</td>
<td>8 (1)</td>
<td>Ms. V</td>
<td>5 (1)</td>
</tr>
<tr>
<td>Mr. A</td>
<td>8 (3)</td>
<td>Mr. K</td>
<td>2 (2)</td>
</tr>
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</tr>
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<td></td>
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Findings: Nature of Principle- and/or Evidence-Based Reasoning

- Carbon
- Water
- Biodiversity

Sophisticated
Transitional
Emergent
Findings: Nature of Principle- and/or Evidence-Based Reasoning by Teacher

Varied implementation of LPTS: principle- and/or evidence-based reasoning
Sophisticated Principle- and/or Evidence-Based Reasoning
Sophisticated Principle-Based Reasoning from Ms. S

• Who looked in the bag? What did you see? Did anybody see anything in the bags besides the plant?
• What kind of moisture?
• What is happening here? Where did this water come from?
• What do you think? Where did it come from?
• Does photosynthesis make water? Where did this water come from? How did it get from the trunk to here? What does that mean? If there’s water in the trunk, how did it get into this bag? A pump, and what did that pump look like?
• So the plant has some cells that have big molecules in them that has lots of energy and the plant is breaking those cells down and water is coming out of them. So the water is coming out of the plant?
Discussion

• Varied implementation of focal LPTSs

• Questioning to prompt Principle- and/or Evidence-Based Reasoning

• Socio-Scientific Norms
Future Directions

• Principle- and/or Evidence-Based Reasoning: Questions

• Formative Assessments
References


Please visit the following website for the complete paper:

www.pathwaysproject.kbs.msu.edu

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Data Analysis: Video Coding Cycle 1

Segments: Parts of a lesson delineated by topic and purpose.
For example, a teacher might introduce a process tool; the students might fill it out individually, then discuss their answers in a small group, and then share out to the rest of the class; and then the teacher connects the process tool to TE’s big idea.

Discussions: Parts of segments where a teacher interacts with one or more student.
• Interaction is about content (not about attendance, discipline, etc.).
• Interaction includes at least three turns of speech.
• Ends based on teacher’s signal.
Data Analysis:
Video Coding Cycle 1 (cont.)

Productive: Describes a subset of discussions.

- Ties to TE in content and/or LPTSSs.
- Includes more than asking a question and eliciting students’ ideas. A teacher asks: Why? How do you know? What does anyone else think?
- Connects/links between at least two concepts OR two dimensions of a concept.
Data Analysis:
Nature of Implementation

Principle- and Evidence-Based Reasoning:

• **Principle-Based Reasoning:**
  – Use of a principle, e.g.: such as gravity.
  – Are the students talking about some driving force/principle?

• **Evidence-Based Reasoning:**
  – data and/or observable events
  – Are the students talking about a reason why based on something they actually observed?

• **Both:** intertwined and sequential
Sophisticated Principle- and/or Evidence-Based Reasoning
Sophisticated Principle- and/or Evidence-Based Reasoning
Data Analysis

To answer question 2:

How did the curricular materials support (or not) teachers’ use of the focal strategy of principle- and/or evidence-based reasoning?

• Examined sophisticated implementation of principle- and/or evidence-based reasoning
Findings: Curricular Materials

- Sophisticated instances of LPTS: principle- and/or evidence-based reasoning
  - Carbon:
    - Activities, readings, a quiz, the process tools, a warm up, and "evidence buckets"
  - Water
    - Discussing the Formative Assessment Map, PowerPoint presentations, examining a map of an actual school campus, and an individual/small group/whole class activity that explored local rainfall data
### Pathways Case Study

**Teacher Participants and Topics**

<table>
<thead>
<tr>
<th>Region</th>
<th>Biodiversity TE</th>
<th>Carbon Cycle TE</th>
<th>Water Cycle TE</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Coast</td>
<td>2 (HS)</td>
<td>1 (HS)</td>
<td>1 (HS)</td>
</tr>
<tr>
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<td>2 (HS)</td>
<td>1 (HS)</td>
<td>1 (MS)</td>
</tr>
<tr>
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<td>1 (MS)</td>
<td>1 (MS)</td>
<td>2 (MS, HS)</td>
</tr>
<tr>
<td>West Coast</td>
<td>1 (MS)</td>
<td>1 (MS)</td>
<td>2 (MS)</td>
</tr>
</tbody>
</table>

**HS** = high school and **MS** = middle school

**TE** = Teaching Experiments (6 to 14 lesson instructional units)