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

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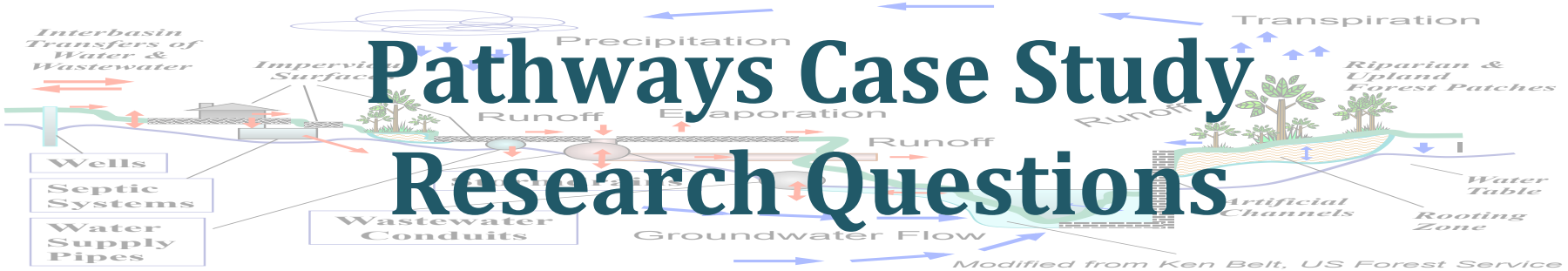
Introduction to Pathways

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.**

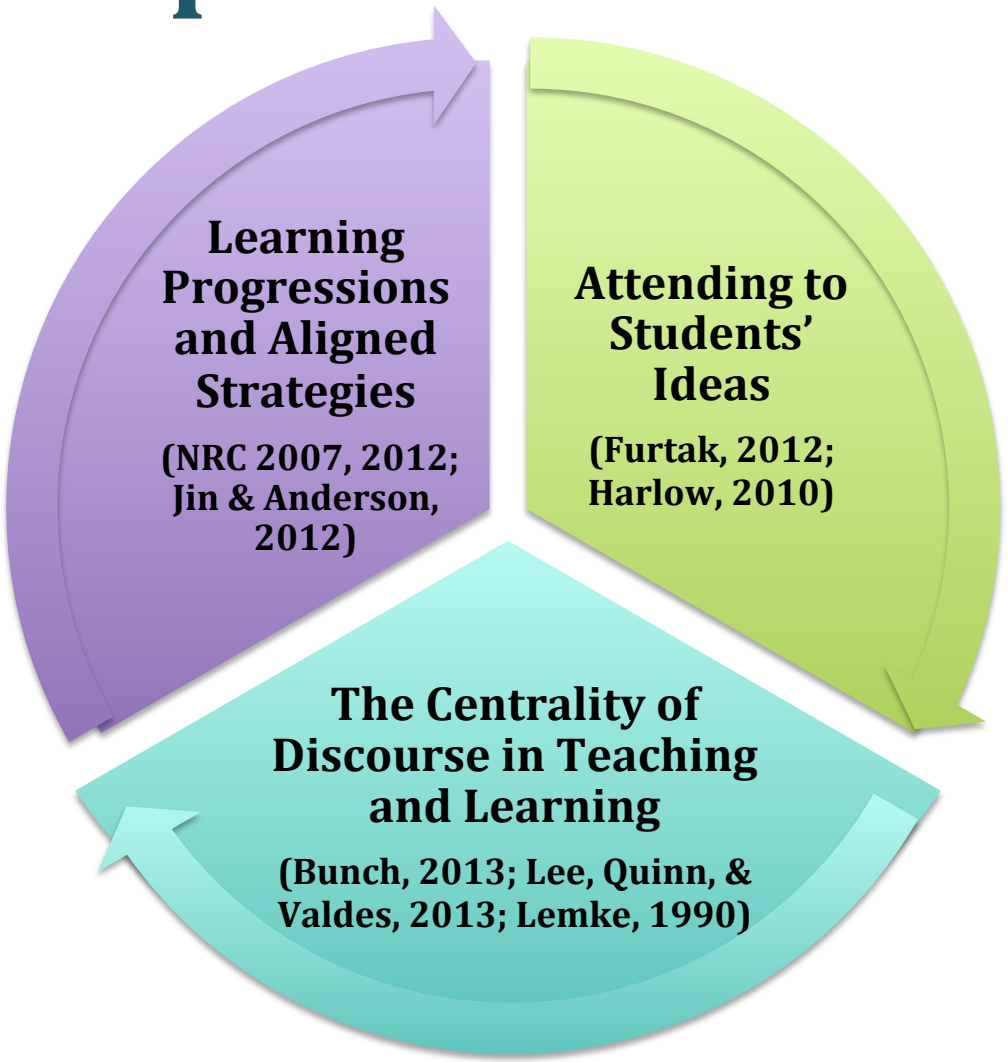
Pathways Case Study Research Questions



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



Pathways LP Levels

Learning Progression Levels
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 (LPTSs)

LPTS 1	**Big Ideas**	**Focus on big ideas in the field of study, supported by LP.**
LPTS 2	**Planning**	**Plan instruction based on student understanding of topic in LP context.**
LPTS 3	**Formative Assessment**	**Develop and use LP-based formative assessments to guide instruction.**
LPTS 4	**Attending to Ideas**	**Carefully attend and respond to students' thinking guided by LP.**
LPTS 5	**Inquiry**	**Guide students in inquiry with authentic events and experiences.**
LPTS 6	**Reasoning**	**Engage students in increasingly complex principle- and evidence-based accounts.**
LPTS 7	**Local Context**	**Link to real problems anchored in students' culture and place.**
LPTS 8	**Citizen Practices**	**Support engagement in science-based citizenship decision-making practices.**

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

Project Themes	Teaching Experiments (TEs)		
	Biodiversity	**Carbon Cycle**	**Water Cycle**
Learning Progressions	Focus on Student Thinking	Focus on Student Thinking	Focus on Student Thinking
	Biodiversity Assessments	Carbon Assessments	Water Assessments
Main Investigation	Leaf Pack Organisms	Plant Growth	School Campus Water Pathways
Citizenship	Evaluating socio-scientific arguments		
Culture and Place	Site- and Context-Specific		

Pathways Case Study Teacher Participants

	West Coast	
Teacher	**Grade**	**TE**
Ms. E	MS	Carbon
Mr. K	MS	Water
Ms. L	MS	Water
Ms. Z	MS	Biodiversity

	Mountain	
Teacher	**Grade**	**TE**
Ms. S	MS	Carbon
Mr. J	MS	Water
Ms. V	HS	Water
Ms. T	MS	Biodiversity

	Great Lakes	
Teacher	**Grade**	**TE**
Mr. G	HS	Carbon
Mr. D	MS	Water
Ms. F	HS	Biodiversity
Ms. R	HS	Biodiversity

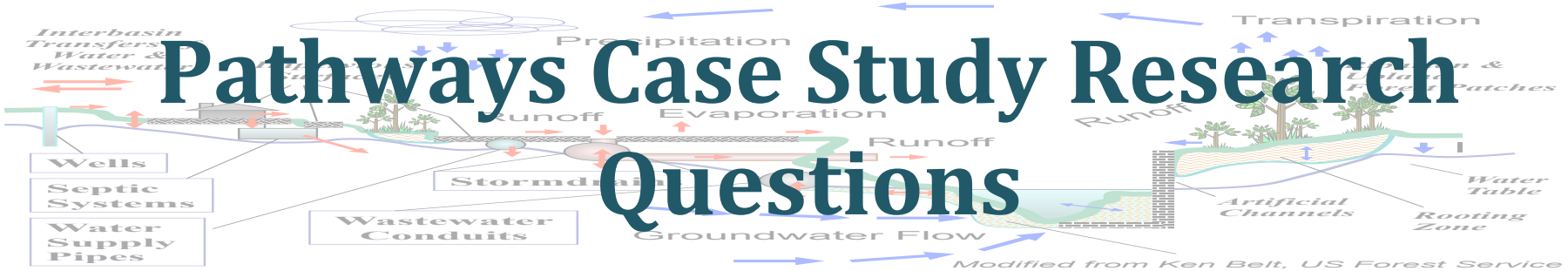
	East Coast	
Teacher	**Grade**	**TE**
Mr. A	HS	Carbon
Ms. P	HS	Water
Mr. B	HS	Biodiversity
Ms. M	HS	Biodiversity

LPTS Principle- and/or Evidence-Based Reasoning Necessary for Movement

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 th[at] 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)

Data Analysis

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

LPTS 1	Big Ideas	Focus on big ideas in the field of study, supported by LP.
LPTS 2	Planning	Plan instruction based on student understanding of topic in LP context.
LPTS 3	**Formative Assessment**	**Develop and use LP-based formative assessments to guide instruction.**
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LPTS 7	Local Context	Link to real problems anchored in students' culture and place.
LPTS 8	Citizen Practices	Support engagement in science-based citizenship decision-making practices.

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

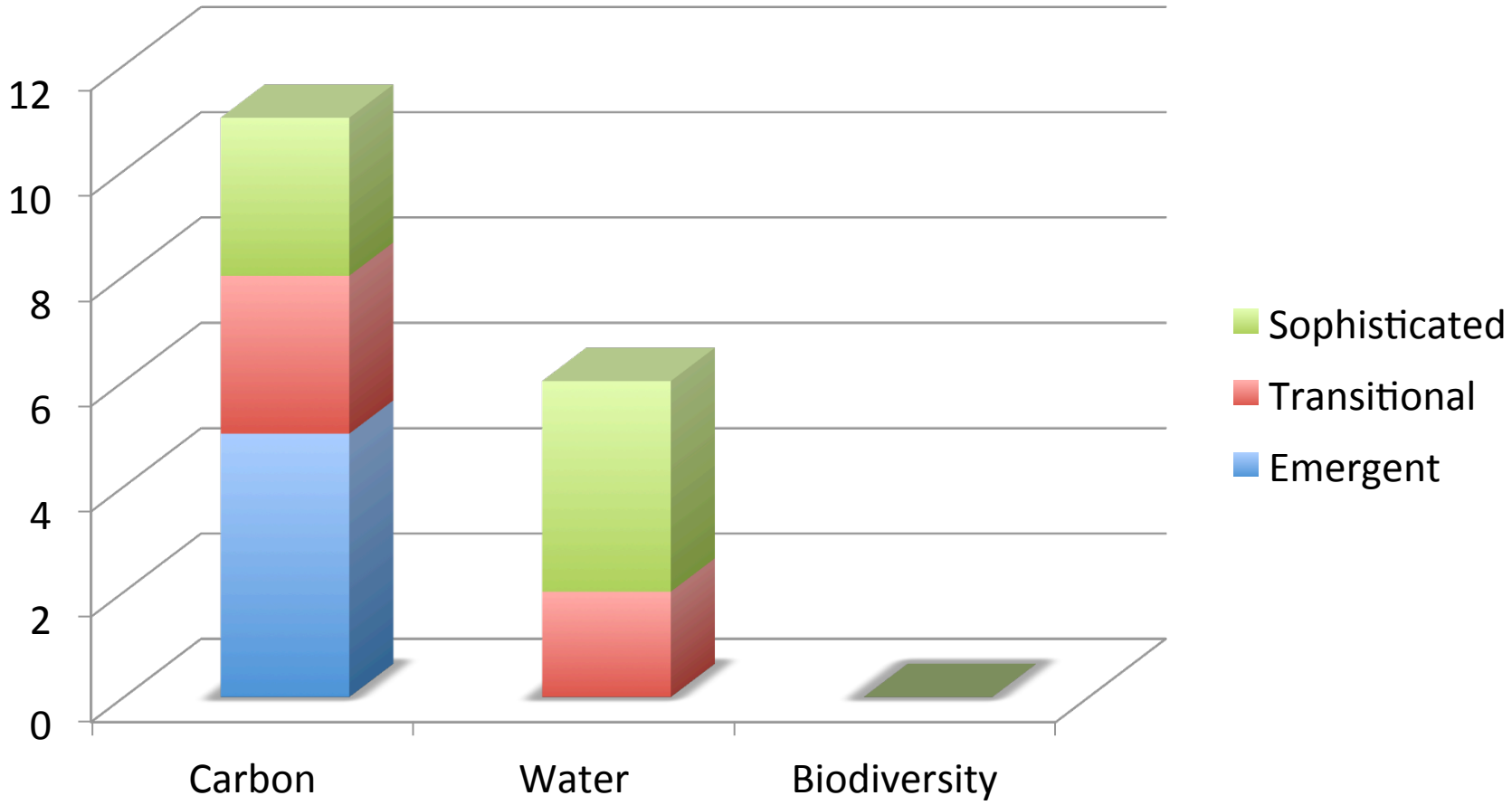
1. **How did teachers implement the two focal strategies in their classrooms?**

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

Carbon (4 of 4)		Water (3 of 6)	
Teacher	No. of Instances	Teacher	No. of Instances
Ms. E	5 (2)	Ms. P	3 (2)
Mr. G	3 (3)	Ms. L	2 (1)
Ms. S	2 (1)	Mr. J	1 (1)
Mr. A	1 (0)		

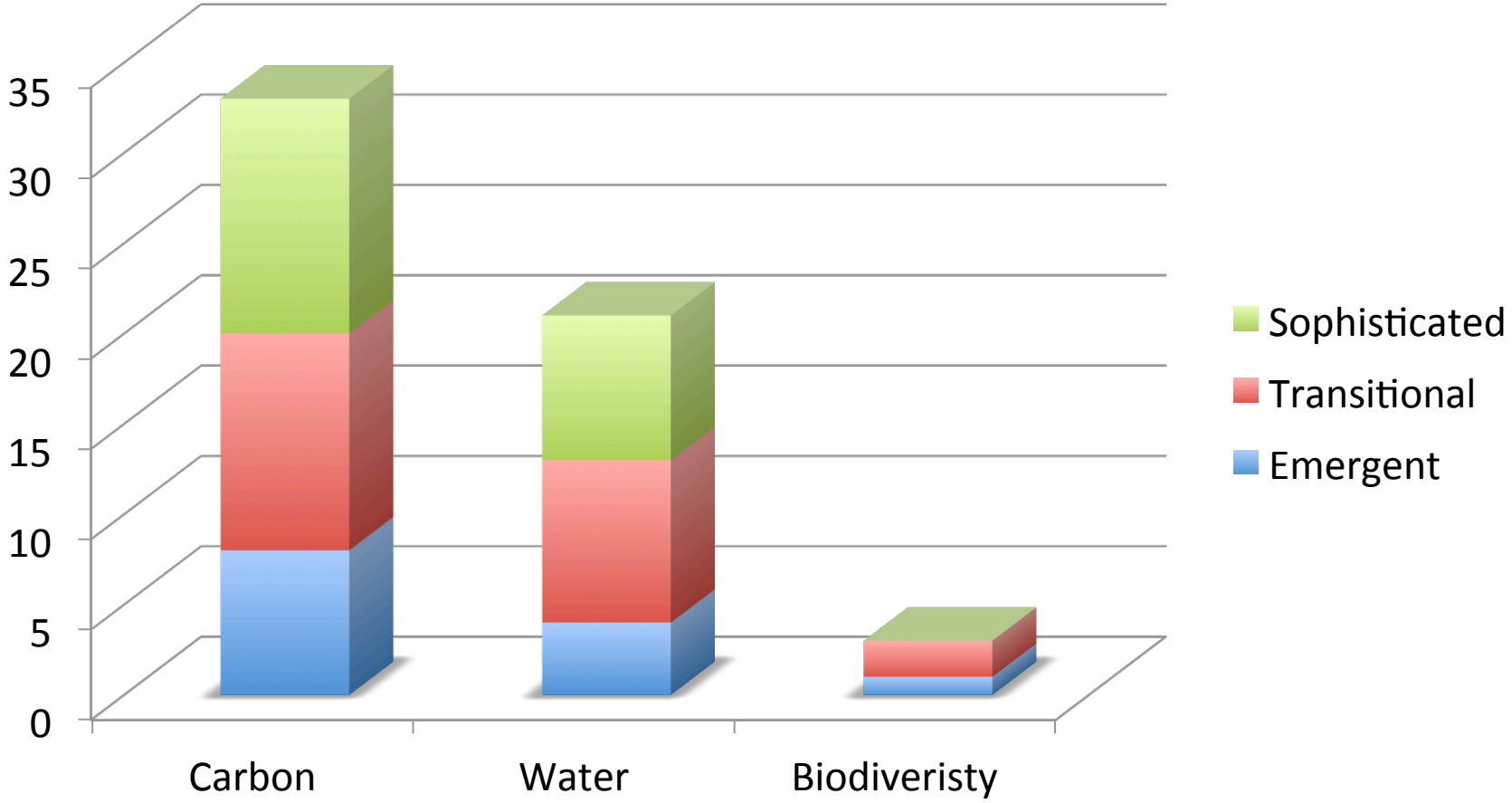
Findings:
Nature of Formative Assessments



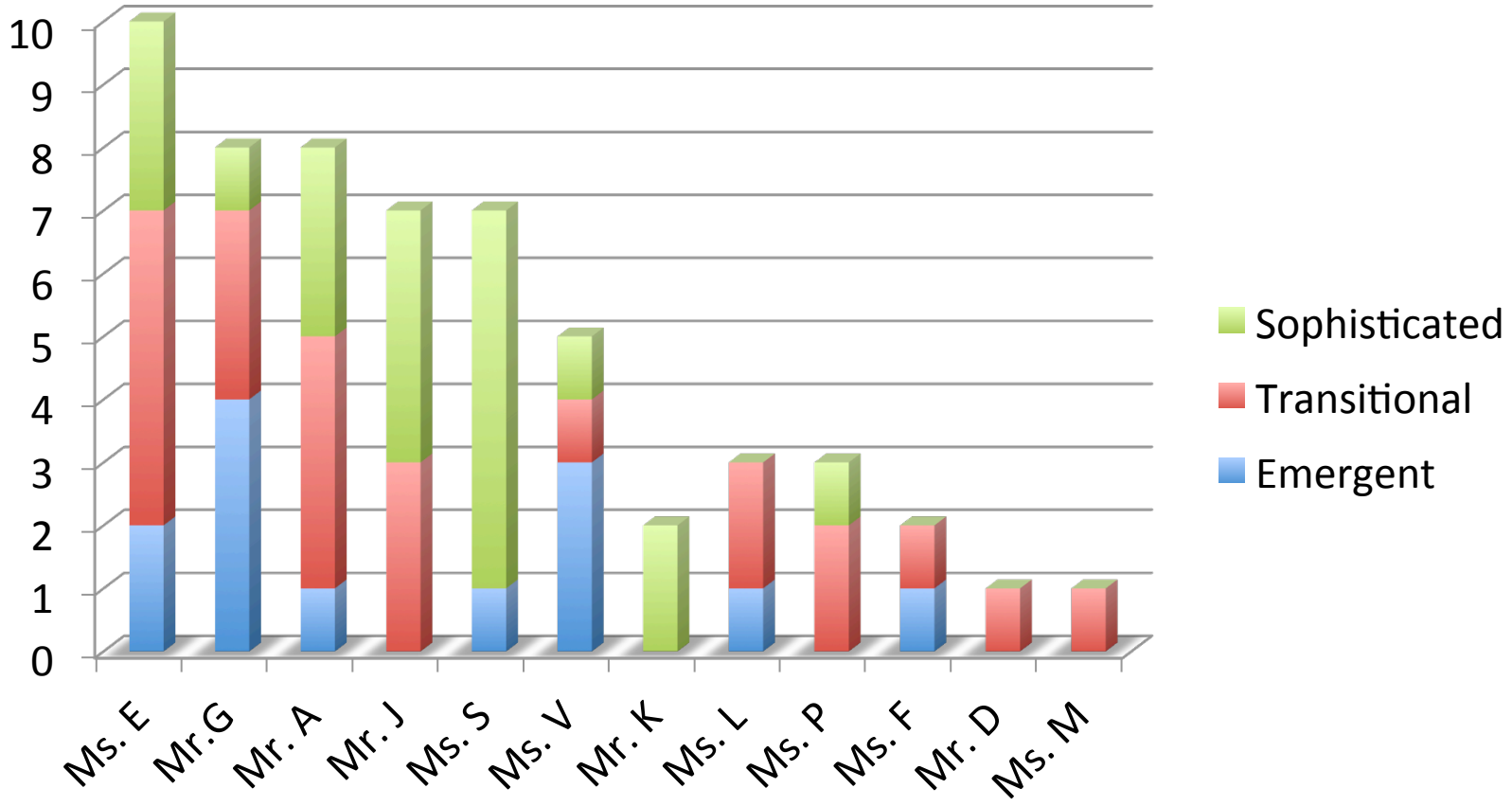
Findings:
Instances of Principle- and/or Evidence-Based Reasoning

Carbon (4 of 4)		Water (6 of 6)		Biodiversity (2 of 6)	
Teacher	No. of Instances	Teacher	No. of Instances	Teacher	No. of Instances
Ms. E	10 (3)	Ms. J	7 (4)	Ms. F	2 (0)
Mr. G	8 (1)	Ms. V	5 (1)	Ms. M	1 (0)
Mr. A	8 (3)	Mr. K	2 (2)		
Ms. S	7 (6)	Ms. P	3 (1)		
		Ms. L	3 (0)		
		Mr. D	1 (0)		

Findings:
Nature of Principle- and/or Evidence-Based Reasoning

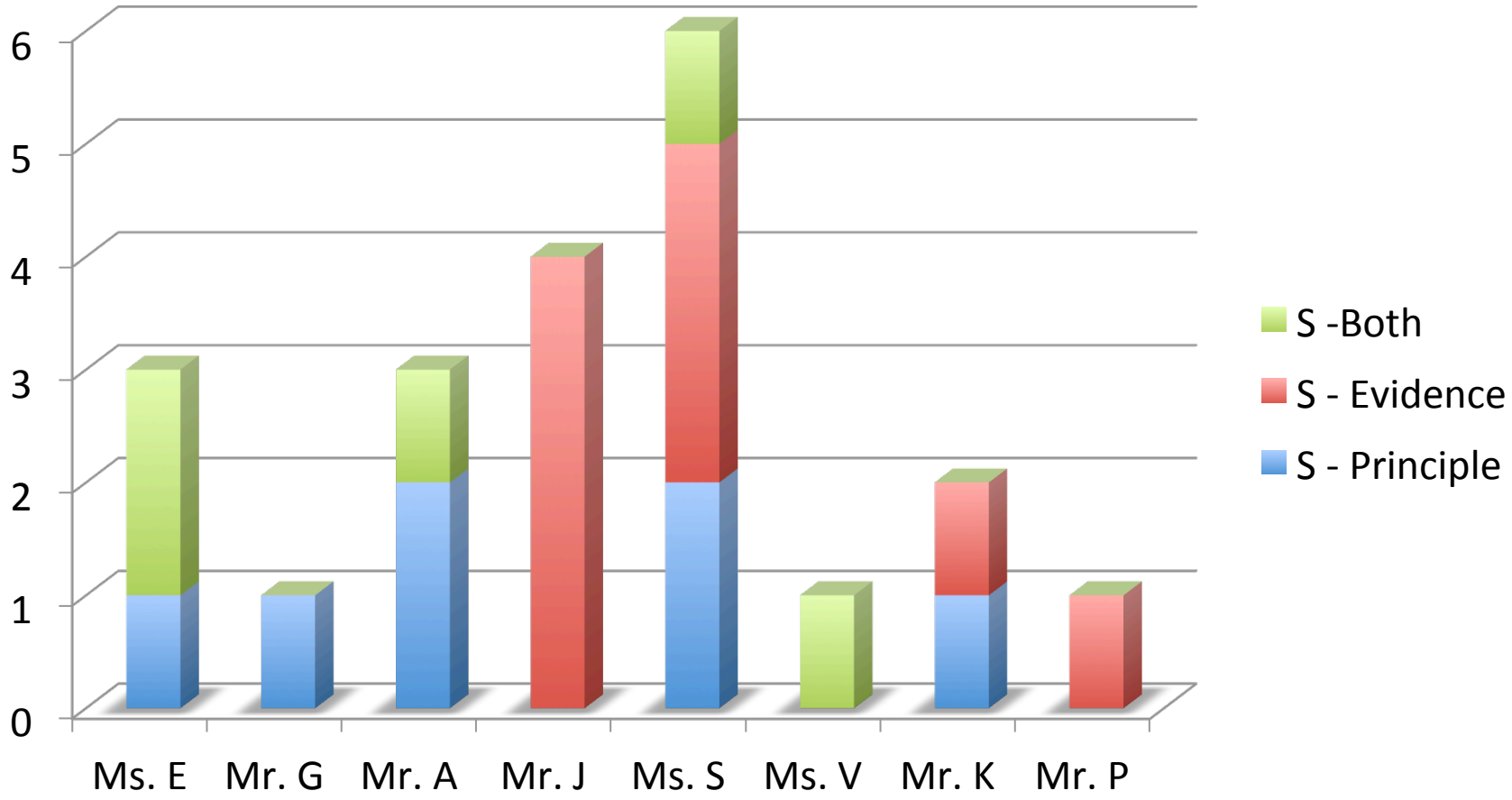


Findings: Nature of Principle- and/or Evidence-Based Reasoning by Teacher



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**

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Please visit the following website for the compete 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.

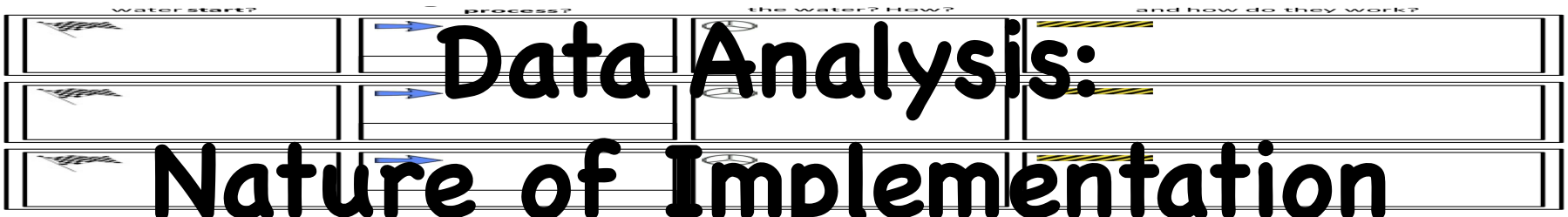
Discussions: **Parts of segments where a teacher interacts with one or more student.**

- 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 LPTSs.**
- **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

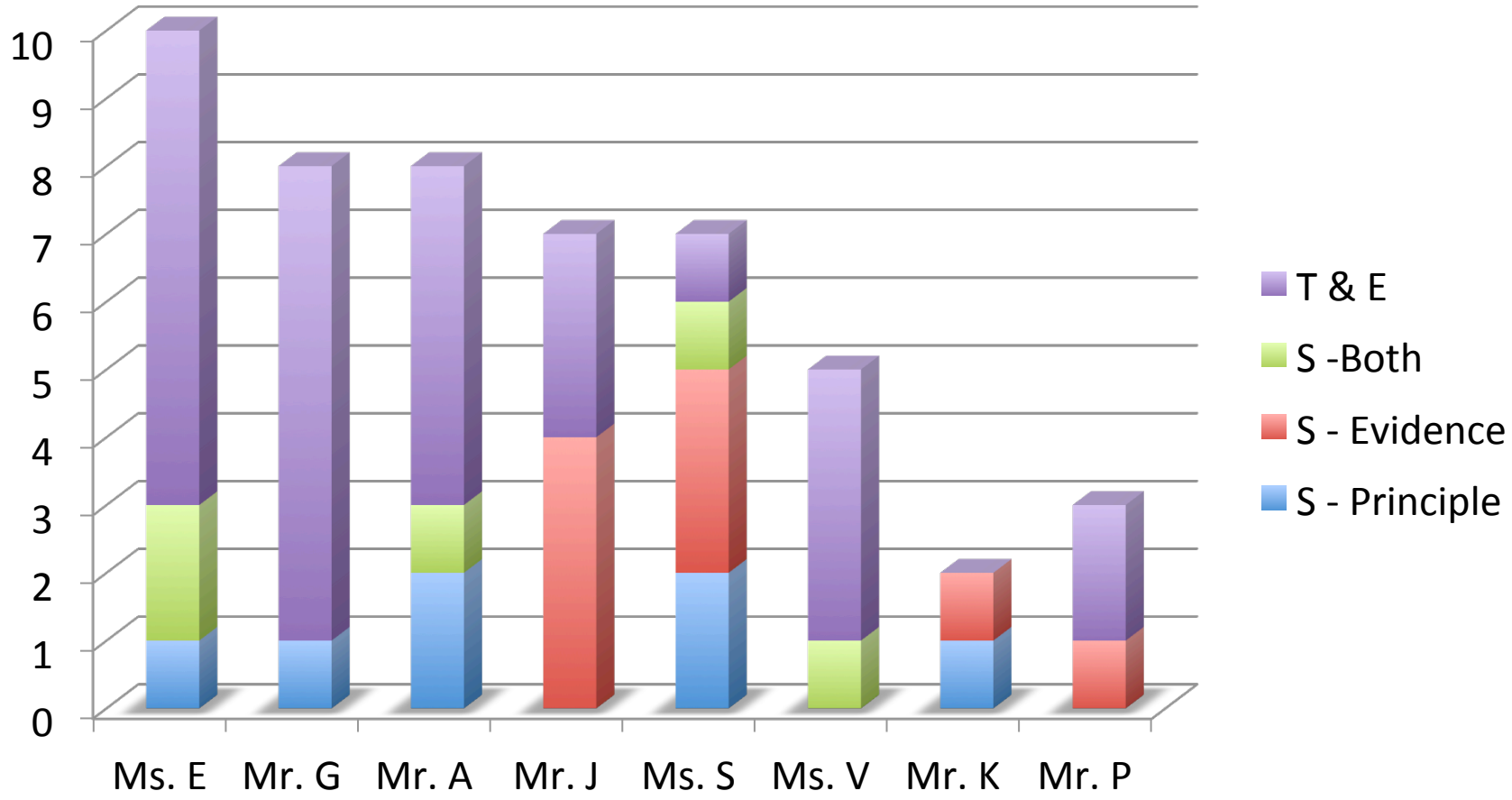
Principle- and Evidence-Based Reasoning:

- **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



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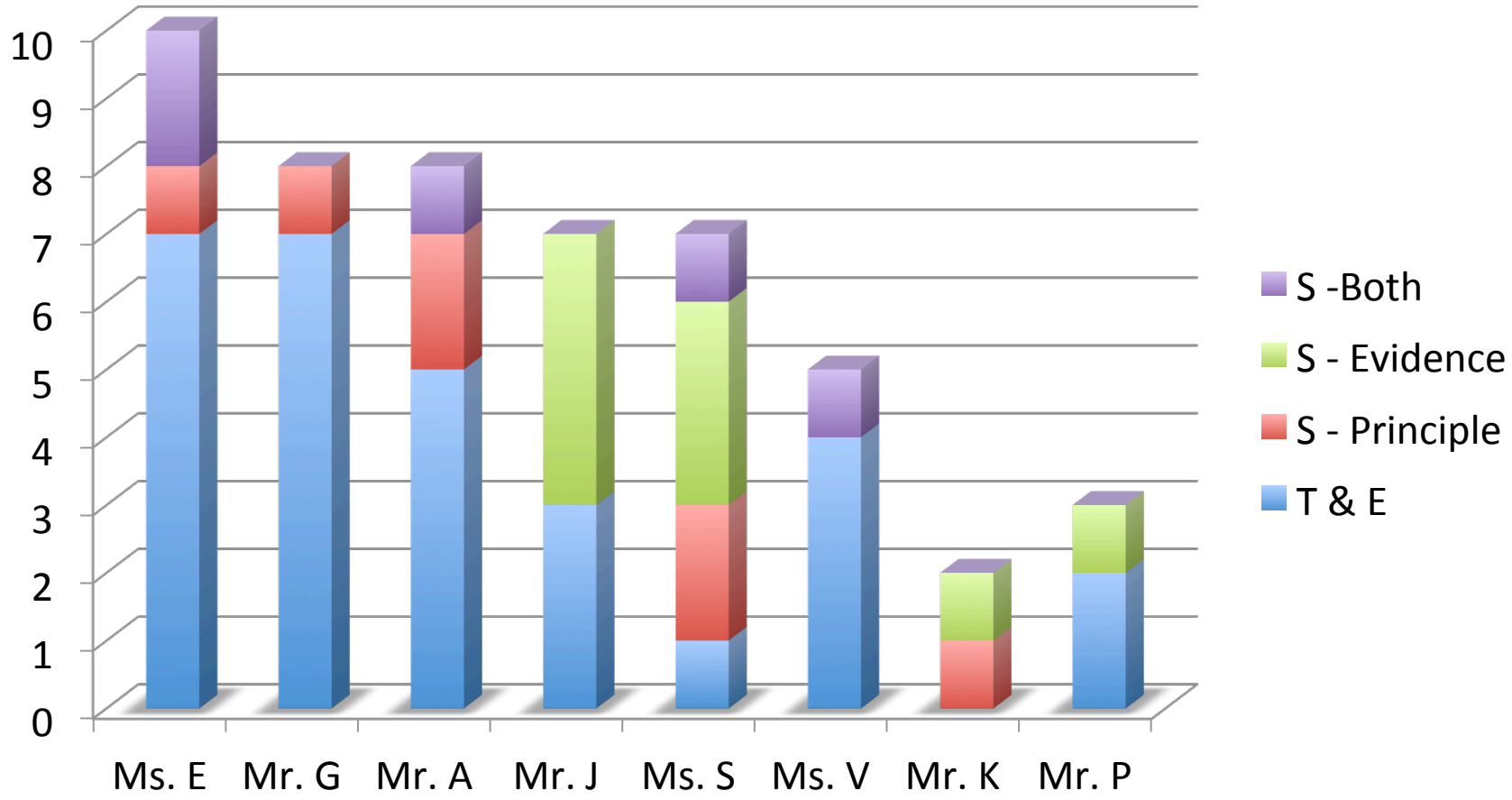

Data Analysis

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

Region	Biodiversity TE	Carbon Cycle TE	Water Cycle TE
East Coast	2 (HS)	1 (HS)	1 (HS)
Great Lakes	2 (HS)	1 (HS)	1 (MS)
Mountain	1 (MS)	1 (MS)	2 (MS, HS)
West Coast	1 (MS)	1 (MS)	2 (MS)

HS = high school and MS = middle school
TE = Teaching Experiments (6 to 14 lesson instructional units)