Learning Progressions in Scientific Inquiry

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Project Goals

- To understand how teachers may progress in attending and responding to student thinking in facilitating scientific inquiry
- To understand how students may progress in their abilities to engage in scientific inquiry
- To develop curriculum materials that support inquiry-oriented science classrooms in the 3rd - 6th grades.

Activities and Findings

Scientific inquiry

- The pursuit of coherent, mechanistic accounts of natural phenomena [Hammer, 2004]

Curriculum Development

- Developed responsive modules for 3rd grade (toy cars), 4th grade (electric circuits), 5th grade (water cycle) and 6th grade (composting).
- Each module starts with an opening task to generate lots of student ideas, which then become the focus of follow-up discussions and activities.
- Some suggestions for possible follow-up activities are provided, but what actually happens depends on the individual classroom dynamics. (See middle panel.)
- Each module implementation runs for 14-20 hours.

Professional Development

- During summer workshops and bi-weekly school year meetings teachers engage in scientific inquiry, in analyzing their own classroom video to practice identifying and responding to students' ideas and reasoning, and in preparing for module implementation.

Learning Progressions

- Focusing on inquiry practices rather than specific scientific content
- Progress is episodic and context dependent rather than linear and in stages, both for students (Sikorski et.al., 2009) and teachers (see right panel).

Findings for Students

- Using mechanistic reasoning and seeking coherence (Sikorski et.al., 2009) is rich in our classroom data, but is episodic
- Framing activity as building, rather than as explaining or experimenting, seems particularly common in some contexts (electric circuits) and helps to account for some student activity (Winters and Hammer, 2009).

Findings for Teachers

- 8 teachers during year 1 and 14 teachers during year 2 (grades 3-6)
- Over the first year of classroom implementation all teachers provided more opportunities for students' ideas to take center stage in classroom discourse
- All teachers became better able to attend to the substance of students' ideas during professional development meetings, but some had difficulty to do that well during classroom module implementations
- Two teachers were studied in depth and we found that framing was a useful construct to understand and account for some of their classroom behavior. (See panel to the far right.)

Responsive Curriculum

Opening Questions

- **Third grade toy car module**: *How can you get a toy car to move?*
- **Fifth grade water cycle module**: *Suppose that one night it rains. When you arrive at school, you notice that there are puddles of rainwater in the parking lot. When you go home, you notice that the puddles are gone. What happened to the rainwater?*

Students' Ideas

- Students suggest many ideas in response to the opening question, and teachers are encouraged to decide next moves based on the 'substance' of those ideas.
- By teachers being responsive, the students' ideas and reasoning that emerge in whole class and small group discussions provide data that informs our development of a student learning progression in scientific inquiry.
- In our teachers' classrooms issues arose that drove classroom discussion for extended periods, providing substantial opportunities for students to engage in meaningful scientific inquiry. An example from the toy car module is provided below.

Example from two classrooms: Faster versus Farther

During day 2 of Mrs. Varga's implementation of the toy car module the kids are discussing ways of making a toy car move faster. One student, Jane, talks about a pullback car:

Jane:	*You could pull it back, and you could pull it back a little further and it will go a little faster. (…)*
Mrs. Varga:	*The further I pull it back, the faster it's going to go?*
Jane:	*Yes*
Adam:	*No, it's just going to go. I'll probably go farther, but like the same speed.*
Mrs. Varga:	*Adam just brought up another thing. … We talked about ways to make it go faster. How do we make it go further?*

In being responsive, Mrs. Varga invites the class to consider another question, how to make the toy car go further. The faster versus further issue became a common discussion point over several periods as students considered making various types of toy cars move more quickly or travel a greater distance.

During day 7 of Mrs. Farmer's implementation students set up an experiment to determine how the steepness of a ramp might affect how fast a car goes. They found that the car that went down the shallowest ramp was the only one that made it to the finish line (some distance from the ramps). The other cars tumbled at the bottom of the steeper ramps and didn't go very far. Students concluded that the car that went down the shallowest ramp was the fastest because it went the furthest. The next day, after further discussion about the ramp experiment, the class had the following discussion:

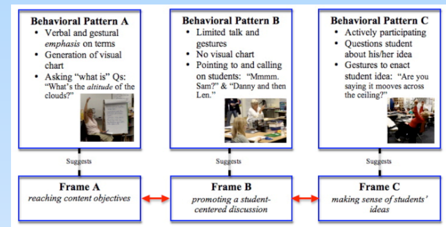
Mrs. Farmer:	*But then there was this question of how will we know if something went the fastest. How can we tell? (…) Fernando?*
Fernando:	*It's the first one that goes down.*
Mrs. Farmer:	*So Fernando is suggesting that the first car that goes down is the fastest, but this group (pointing to a group's presentation board) suggested that (the car going down the shallowest ramp) went fastest because it went further. Is that what you said, Fernando? (…)*
Fernando:	*It doesn't matter if it goes farther. It, um, because some of they, some of them (holding arm slanted downward) are like them, they may be the real ones that go quick (moving palm of hands quickly downward), but just crashes. (…)*
Mrs. Farmer:	*So it might go really, really fast, but it doesn't go very far because it just crashes. But it still might go really fast.*

In this interchange Fernando challenged the claim that the car that went furthest was the fastest. The issue was not settled for the students at this time, but the discussion about faster versus further continued over the next several days when students considered races between rubber-band launched cars versus cars going down ramps.

Teachers' Classroom Practices

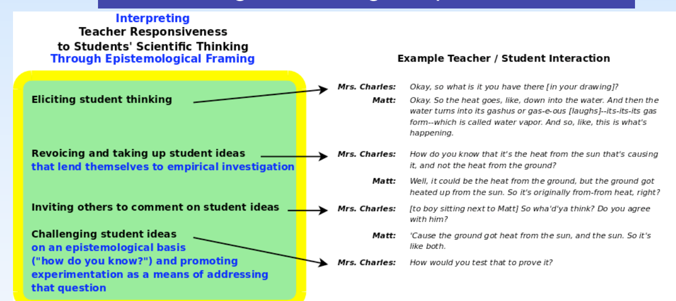
- The theoretical construct of *framing* can provide a means by which to make sense of different teachers' practices. Loosely speaking, framing is a person's answer to the question, "What is it that's going on here?" (e.g. Scherr & Hammer, 2009; Tannen, 1993)
- Below are examples from two 5th grade implementations of the water cycle module that illustrate how we use framing to help understand what it is the teachers are doing.

Different Ways to Frame Instruction



- Coordinating Mrs. Miller's verbal and non-verbal behavior in-module showed at least three distinctive patterns, stable for at least several interactions (Lineback and Goldberg, submitted).
- Mrs. Miller did not proceed from one frame to another sequentially; rather she moved between them episodically (Lineback and Goldberg, submitted).

Framing Influencing Responsiveness



- *Responsiveness* (Pierson, 2008) is a measure of the extent to which teachers take up and use student reasoning in their classrooms. The teacher moves printed in **black** above are adapted from follow-up moves Pierson (2008) identified as 'High II Responsiveness'.
- In our analysis of one 5th grade teacher's follow-up moves, we found responsiveness insufficient to account for what was happening as she facilitated scientific inquiry (Maskiewicz and Winters, submitted).
- We found that interpreting teacher responsiveness to student thinking in terms of her epistemological framing of scientific inquiry allowed us to uncover nuances in how she attends to and follows up on student ideas (Maskiewicz and Winters, submitted).

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