Defining Learning Progressions for Scientific Inquiry

Tiffany-Rose Sikorski[1], Victoria Winters[2], David Hammer[1]
[1]University of Maryland, College Park [2]San Diego State/UC San Diego

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Introduction

Scientific inquiry is **"the pursuit of coherent, mechanistic accounts of phenomena"** (Hammer, Russ, Mikeska, & Scherr, 2008, p. 150). Our goal is to create a learning progression focused specifically on the ways students engage in that pursuit. That is, we take progress in inquiry to be a goal in and of itself, rather than only a means to the goal of "content knowledge."

We expect progress, in this and other aspects of learning, to be *episodic*: rather than presume to find a sequence of attainments, we expect multiple, at first sporadic beginnings becoming more stable over time. We use one aspect of inquiry—coherence seeking—to illustrate our theoretical framework and to highlight challenges and benefits of our approach.

Methods

❖***Participants***
- 6 elementary teachers & their students
- 2 middle school teachers & their students

❖***Curriculum Modules***
- Motion (3rd and 4th grade)
- Electricity and circuits (4th grade)
- Water cycle (5th grade)
- Ecology (6th grade)

❖***Data Sources***
- Classroom video from module implementations
- Field notes
- Classroom artifacts
- Additional classroom video at teachers' discretion

❖***Data Analysis***

-Review data sources for evidence of student C-S.

- **Evidence of Coherence Seeking (C-S)**

***Looking for Consistency*:**
Identify an inconsistency, request or offer reconciliation for an inconsistency, indicate that a result or observation is unexpected

***Looking for Meaningful Relations*:**
Request or identify a meaningful relationship between ideas, identify an unexplained phenomenon, offer reconciliation of an inconsistency

- Identify contextual features that facilitate/impede C-S, and other inquiry aspects linked to students' C-S.

Emerging Questions

❖In what contexts do students seek, or not seek, coherence?

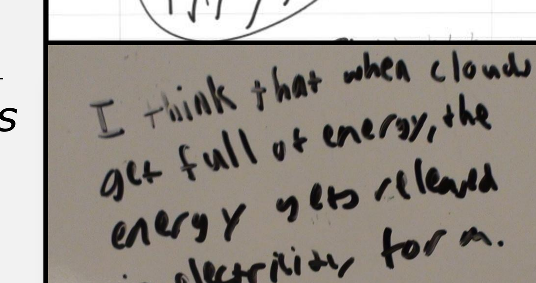
❖What features of a situation cue, or tend to inhibit, coherence seeking?

❖What empirical methods are necessary to describe a learning progression that is episodic in nature?

Theoretical Framework: The Example of Coherence Seeking

Characterizing a Learning Progression in Inquiry	**Resources Perspective** -Students possess resources for engaging in scientific inquiry. - Students' activation of these resources is context-sensitive. (Hammer, 2004)	**Characterizing Progress** - Progress will be episodic, with students spontaneously engaging in sophisticated inquiry practices before doing so stably. - Define progress as more stable (frequent & sustained) engagement in inquiry practices over a wider variety of contexts (disciplinary & social).	**Mechanisms of Progress** - Framing: forming expectations for what takes place in learning, e.g. forming a sense that reasoning in science involves drawing on everyday knowledge - Developing & refining resources for engaging in inquiry
Preliminary Work in Coherence Seeking	Students possess resources for C-S: - HS students can attend to causal coherence with technological scaffolding (Sandoval, 2003) - Elementary students can "recognize inconsistency in the thoughts of others" (Smith, Maclin, Houghton, & Hennessey, 2000, p. 364)	- Use instances from classroom data to build a description of gaining expertise in coherence seeking - Progress in coherence seeking may be inextricably linked to progress in other aspects of inquiry, i.e. modeling, mechanistic reasoning & argumentation.	Framing of science as a coherence-seeking activity may be more likely to occur when: - students' ideas are made central to classroom activities - students reason about phenomena familiar to them

Student Behavior	Example from Classroom Data
Identify an inconsistency between: • Two or more pieces of information • A claim, prediction, or explanation and two or more pieces of information	*"…how could a magnet have electricity in it because, isn't a magnet metal too? sort of? If it had electricity in it, it would go out. Because once electricity hits metal it goes, it keeps going in the metal until it goes—until there's no other metal on to for it to travel through and then it goes out."* The student identifies an inconsistency between two pieces of information (electricity goes through metals, magnets are metal) and another student's claim that magnets have electricity in them.
Offer reconciliation of an inconsistency	A student finds that, contrary to his prediction, the asphalt from which a puddle evaporated is cooler than the surrounding asphalt. He offers a reconciliation: *" I think the water kind of acted like a cover for the asphalt for a few moments. So it, so that it, so this [asphalt] started to heat up, so it was like putting a cover over this so this doesn't heat up as fast…"*
Identify a relationship between ideas, i.e. • cause and effect • part-to-whole • category and example • temporal/chain of events	*"…She said that it was heat coming up. Me and Robert were thinking maybe it's like um cause and effect. Heat is the cause and the water vapor is the effect."* Students are debating what the "stuff" is that they see rising from an evaporating puddle—steam, water vapor, or heat. As part of her argument that it is not heat, the student identifies a cause and effect relationship between heat and water vapor.
Identify an unexplained phenomenon	*"…if they [clouds] need to get rid of their energy and it turns into electricity, why does that only happen in certain areas? …Some areas they have like storms and rain and uh everyday. Um, why does that not happen here?"* The student recognizes that another student's idea (that clouds have to get rid of energy) does not explain why some places are stormier than others. In other words, there is a *missing relation* between the idea that clouds have to expel energy and the observation that clouds do not *always* expel energy.



Extended Example:
Raphael and the Cold Clouds

In response to Raphael's question about clouds being cold, students enter into period of relatively stable engagement* in coherence seeking:

Raphael: And also, I know this is kind of off our main question but, I just thought like since the the clouds are so high, high up and it's cold, and the sun, and they're closer to the sun than we are, why is it cold? [identify inconsistency]

…

Nick: Um, actually, might because the atmosphere and the cloud cover um that it won't be—that it could get cold. And um, the sun probably isn't right where we are at that point. It could be somewhere else around the Earth. [offer reconciliation]

Raphael: Yeah but they're still freezing. And it's still freezing above the Earth with or without the clouds. (Student: okay) So why? I mean cuz the sun is right there closer and we still have the hottest days when the clouds are sitting up there freezing. [request reconciliation]

Evan: That's because of the sun rays are straight (Raphael: What!?) when it's hot. [offer reconciliation]

Dante: Yeah, because the sun rays are um are straight they're hotter. When they're diagonal they're cooler. [offer reconciliation]

…

Louis: Well in space, even if you're facing the sun it's freezing. *[to Raphael]* Why do you think that? It's closer to the sun. [identify inconsistency]

*2 ½ minute excerpt taken from a 5th grade water cycle module discussion