How Do Students' Framings Hinder or Promote Their Progressions towards Scientific Reasoning?

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Research Background

In previous studies, we have developed a Learning Progression Framework (LPF) for carbon in socio-ecological systems (Jin & Anderson, 2012; Mohen, Chen, & Anderson, 2009). We used this LPF to develop a Plant Unit that promotes student learning of an important science topic—plant growth. In particular, we focus on using scientific reasoning about matter and energy to explain two macroscopic phenomena related to plant growth: 1) Plants gaining weight; 2) Plants exchanging gases (i.e., carbon dioxide and oxygen). The scientific reasoning requires tracing matter and energy in photosynthesis and cellular respiration.

We conducted teaching experiments, where teachers used the Plant Unit to teach. We reported results about how teacher knowledge was linked to student learning outcomes in a previous publication (Jin, Shin, Johnson, Kim, & Anderson, in press). In this study, we examined how classroom dynamics shaped student learning. In particular, we are interested in how students' framings hinder or promote their progression towards scientific reasoning.

Research Questions

- What framings do students take to construct explanations in class discussions?
- How do students' framings hinder or promote the progression towards the upper anchor?

Conceptual Framework

An individual's framing of a situation is their sense of "what is going on in the interaction" (Tannen, 1993). Framing is a dynamic process, in which individuals may constantly change their frames (Berland & Hammer, 2012).

Learning Progression Framework (LPF)
Level 4. Tracing matter and energy
Level 3. Matter-and-energy Reasoning
Level 2. Hidden Mechanism Reasoning
Level 1. Force-dynamic Reasoning

Framings promoting the progression target scientific mechanisms and science inquiry

Regarding the topic of plant growth, the levels on the LPF are:

- Level 4. Scientific reasoning: Explain the two phenomena (plants gaining weight and exchanging gases) based on tracing matter and tracing energy in photosynthesis and cellular respiration.
- Level 3. Matter-and-energy reasoning: Explain the two phenomena based on common misconceptions of matter and energy.
- Level 2. Hidden mechanisms reasoning: Explain the two phenomena in terms of invisible structures and processes that do not involve matter or energy.
- Level 1. Force-dynamic reasoning: Explain the two phenomena in terms of how plants use enablers (e.g., water, sunlight, soil, people, and air for plants) to grow.

Methods

Participants and Data Sources

Teacher	Region	Grade Band	Gender	Ethnicity	SES of Schools
Ms. E	West Coast	Middle	Female	White	Lower Middle Class
Ms. S	Mountain	Middle	Female	White	Borderline Poverty
Mr. A	East Coast	High	Male	Indian	Middle Class
Mr. G	Great Lakes	High	Male	White	Lower Middle Class

We transcribed and coded two videos from each teacher's class.

Data Analysis

1. Developing the Coding Scheme:
   - For each video, we selected classroom discussions where the teacher explicitly or implicitly required students to explain WHY or HOW they thought an answer was right or wrong, because students' responses in those instances provided information about their framings. These selected discussion sections were transcribed for coding.
   - We segmented the selected discussions into episodes. Each episode contained teacher-student conversations about one question.
   - We used the constant comparative method to identify students' framings. Based on this work, we developed a preliminary coding scheme.
2. Developmental Coding
   - Two coders used the coding scheme to code two videos from different teachers independently. The differences between the coders were reconciled through revising the coding scheme.
3. Full Coding
   - Two coders used the coding scheme to code each video independently. The difference between the coders were discussed and resolved.

Results

Finding 1. Framings That Hinder Learning

Students may take framings that hinder learning:

- Knowledge Matching Framing
- Heuristics Framing
- Covering Law Framing

Covering Law Framing (CL)

The student uses a scientific principle or a commonsense statement to support a claim, and does not provide any causal mechanisms. The covering law type of explanations is discussed in a paper by Braaten and Windschitl (2011).

Teacher: Is there any other conclusion we could draw from increasing our carbon dioxide as we look at the soda and then also having that weight decrease, what else could we draw from that?
Student D: Everything has mass, even gases.

Knowledge Matching Framing (KM)

The student provides a piece of matching knowledge—a statement or a term that matches the information provided in the teacher's question, but does not explain the question.

Teacher: Some of you say yes. Some of you say no. Let me first ask people who said yes. How do you know that my whole body is made of carbon?
Student A: Carbon, like, in a formula, like H, O and carbon. The carbon is in the formula, whatever.
Teacher: The carbon is in the formula.

Heuristics Framing (HE)

The student uses heuristic thinking, or in other words, system 1 thinking to answer the question. Systems 1 thinking is "effortlessly originating impressions and feelings" (Kahneman 2011, p. 21).

Teacher: My next question is, since you mentioned all these things. OK. Plants need them. How do you know that plants need them? How do you know that plants use water to grow?
Student C: Because plants are living things, and we are living things. We need those things.
Teacher: Plants are living things and we are living things. We need water, so plants need water.

Finding 2. Framings That Promote Learning

Students may take framings that promote scientific reasoning.

- Mechanisms Framing
- Inquiry Framing

Inquiry Framing (IN)

The student does not provide the answer, but instead proposes an experiment or an approach to find out the answer to a question.

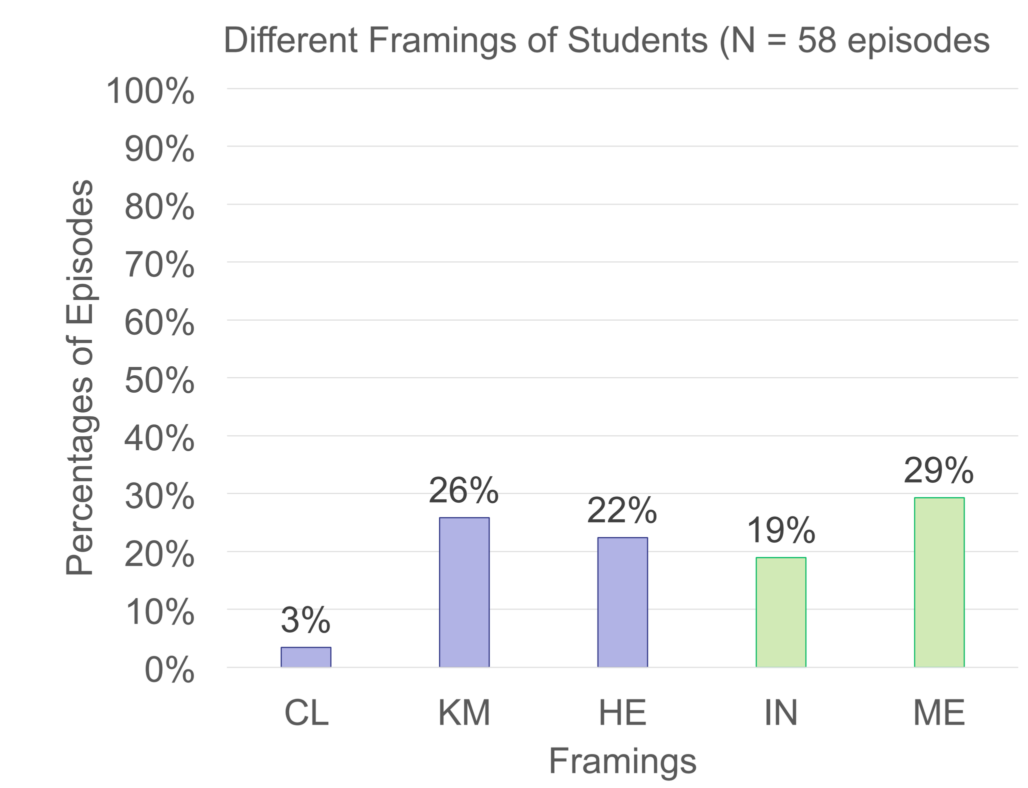
Teacher: So some of the soil's gonna be gone, 'cause he's gonna weigh it and it's gonna be less, if the plant's absorbing the soil? Any other ideas?
Student F: When he gets the weight from the soil, and he takes it away, that's probably why he weighs it.
Teacher: Ok.
Student F: I think he was looking at if it uses just the water, or just the soil, or if it uses air and sunlight and things like that.
Teacher: And how would this experiment tell him that?
Student F: If the plant possibly weighed more than what the soil and the plant were combined afterwards, pretty much it used something else than just the water and the soil.

Mechanisms Framing (ME)

The student reasons about the mechanism that explains a cause and effect relation.

Teacher: When I was breathing in the probe to kinda get it going, you guys noticed that it kinda jumped up in parts per million? The carbon dioxide, right? The carbon dioxide increased. So does that mean that if I'm breathing out, if I'm losing carbon dioxide and carbon dioxide has weight, does that mean that I'm losing weight, or mass when I breath out?
Student E: Well since when you breathe out carbon dioxide you also breathe in oxygen, so it might be the same.
Teacher: So it might be the same because as I'm breathing out carbon dioxide I then breath in oxygen.

Finding 3. Different Framings of Students



Finding 4. Teachers' Follow-up Questions

Teachers provided different types of follow-up questions, when students took different framings.

- When students took covering law, knowledge matching, and heuristics framings, the teacher's follow-up questions usually did not lead students to think about mechanisms or methods. As a result, students had very few opportunities to be engaged in meaningful science learning.
- When students took inquiry and mechanisms framings, the teacher's follow-up questions usually further pushed students to think about scientific mechanisms and methods. In such situations, students were engaged in meaningful science learning.

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