A Draft Learning Progression for Principle-Oriented Classroom Discourse

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Introduction & Background

This paper builds on previous research on principle-oriented student reasoning. Tracking how students' thinking changed over time in the presence of principle-oriented instruction—while valuable for understanding student learning—provided insufficient evidence to answer questions about how the learning context of a whole classroom supported or hindered principle-oriented Discourse. Preliminary analysis revealed that examining the teacher's instruction in isolation from student participation was also inadequate. For these reasons, we turned our attention away from individual students and teachers, and expanded the scope of study to **whole classroom Principle-Oriented Discourse**:

1. **What are the characteristics of classroom interactions that support Principle-Oriented Discourse?**
2. **What are characteristics of classrooms where Principle-Oriented Discourse does not constrain classroom interactions?**

Data & Analysis

Participants: Middle and high school teachers (n=13) from Carbon TIME Cohort 2 (2012-2013).

Data sources: 1) classroom videos, 2) teacher interviews with students.

Analysis: Interviews and ideos were coded using the principle-oriented framework (Miller et al., 2014) and used to construct a draft learning progression for principle-oriented Discourse.

References: Miller, H. K., Freed, A. L., Doherty, J. H., Johnson, W., & Anderson, C. W. (2014). *Characteristics of Mid-Level Reasoning about Matter and Energy in Carbon-Transforming Processes in Secondary Science Students*. Paper presented at the NARST Annual Conference, Pittsburgh, PA.

Conclusions

Based on our preliminary analysis, we hypothesize that examining how teachers and students use the principles of matter and energy to contrain classroom exchanges will be a valuable lense for constructing a learning progression for classroom Discourse.

Overall, student learning gains do not appear to be predictive of the sophistication of classroom Discourse. Teachers with modest learning gains supported Principle-Oriented Classroom Discourse in their interviews and classrooms: **teachers used the principles of matter and energy as a lens to interpret their students' ideas, and to guide and probe student ideas in whole class and one-on-one settings.**

Interview Results

Fiona's interview with a student using Level 2 reasoning

FIONA: Is it still energy when it enters the tree? Or does it change into other things? And if you think it changes into other things, I just need you to explain to me how.
STUDENT: I would say it's like half and half. Like some of it might still be energy, but some of it might not be energy.
FIONA: That part that's not energy anymore, what would you say that is?
STUDENT: Like the nutrients in the soil probably have some energy, but when they're being absorbed by the tree, they're probably being changed somehow into something else.
FIONA: So the nutrients in the soil are the energy when they're in the soil. And then when it gets taken into the tree, it changes from the energy that was in the soil to something else that's in the tree?
STUDENT: Yeah.
FIONA: Would you still think it was energy in the tree or something else completely?
STUDENT: I would still think it's some sort of energy in the tree.

Here, the student suggested that energy turns into something else.

Fiona noticed this idea about energy immediately. She used the principles as a lens to guide her follow up question. This was consistent throughout.

Fiona veered from the protocol 50 times in this interview.

Richard's interview with a student using Level 2 reasoning

RICHARD: Can you divide the pictures into groups in terms of how matter changes during the event?
STUDENT: [student sorts for 20 seconds]
RICHARD: Alright…Please explain those groups.
STUDENT: The baby girl growth, tree growth, and tree decaying all take more time and more energy to do it.
RICHARD: So remember—I asked you to [tell me] how *matter* changes, so… [emphasis added].
STUDENT: Yeah. Baby girl growth and tree growth can take up more matter than the flame burning, car running, or girl jumping. They all take less space. The tree decaying again can go in either because when it first starts to decay it takes up more space on where it lays rather than when it was alive.
RICHARD. Alright. [transitions to next item].

Richard veered from the protocol 17 times in this interview.

When Richard veered from the protocol it was to get the student "back on track" and stay focused. References to matter and energy were reminders to stay on topic.

Video Results

Ellen structured the discussion around the "Three Questions," and maintained a clear focus on tracing matter and energy.

Ellen structured the discussion around the students' ideas. Questions erved to elicit student thinking, not fill in the blanks.

During discussion, Ellen's students spoke 85 times in 23 minutes.

During discussion, Fiona's students spoke 37 times in 20 minutes.

Fiona mainly used quick-fire questioning and I-R-E style talk to evaluate student ideas and "tell her story." Student voices were prominent, but for quick assessment of correctness.

Ellen teaching the *Systems & Scale* unit (video transcript)

ELLEN: CO_2 has carbon in it and that might be involved. What do you think? Is CO_2 there at the beginning, end, or both?
STUDENT A: Both.
ELLEN: Okay, and how would you know?
STUDENT A: I could know if the BTB changed colors.
ELLEN: If it changed colors, what would it tell us?
STUDENT A: That the carbon in the air was like changing.
ELLEN: The carbon in the air was changing. Other thoughts on the carbon question? Some good thoughts.
STUDENT B: I think that like the carbon is like being released as ethanol burns. So it's going to the air.
ELLEN: And how would we tell if that's actually happening?
STUDENT B: Uh, we could measure the mass of it and see the difference in the mass change and assume that's part of it. And also there is fire…
ELLEN: So you started to bring up the fire. What do you think?
STUDENT C: I think it's related to energy.

Fiona teaching the *Plants* unit (video transcript)

FIONA: Where does the tree get the CO_2?
STUDENT A: The air.
FIONA: Very good. And what part of the tree does it go into?
STUENT B: The leaves.
FIONA: The leaves. Good. So CO_2 is going into the leaves from the surrounding air. And then water. Where is it getting the light energy?
STUDENT C: The sun?
FIONA: From the sun, if it's outside. Where else might they get light energy?
STUDENT D: From our grow light.
FIONA: From our grow light, right.

Draft Learning Progression Framework for Principle-Oriented Classroom Discourse

LP Level	Interview Characteristics	Teachers (Interview)	Teachers (Videos)	Video Characteristics
4	Students' ideas are probed and questioned. The principles of matter and energy are used as lenses to interpret the students' ideas and construct follow up questions. Any veering from the rules in student responses resulted in responsiveness from the teacher.	Ellen, Fiona	Ellen	Exchanges between teacher and student are constrained by the principles of matter and energy. Any divergence from these constraints results in teacher responsiveness. Students' ideas guide the direction of discussions. Teacher uses principles of matter and energy as an interpretive lens to facilitate discussions and form class explanations.
3	Students' ideas are probed sometimes but not others. Principles are used as a lens for interpretation inconsistently.		Ian	Students' ideas played a large role in classroom Discourse, but students did not construct their own class explanations; these came from the materials and the teacher. Principles of matter and energy were used throughout as guides for the discussions.
2	Students' ideas are probed for context-specific knowledge and procedural information. Ideas about matter and energy are largely ignored.		Fiona	Students' voices are prominent, but serve to "tell the teachers' story" with quick, IRE-style exchanges. Principles of matter and energy were consistently present in the teacher's story. Tools (e.g., worksheets, presentations) are used to check for correctness and move on.
1	Focus on student ideas and principles of matter and energy were replaced with a goal to get through the questions and get efficient answers.	Ian, Richard	Richard	Focus on matter and energy and class discussion was replaced with a focus on procedure and grade exchange. Student ideas played nearly no role in class Discourse.

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