Impacts of a Professional Development Program Focused on Helping Teachers Support Student Argumentation

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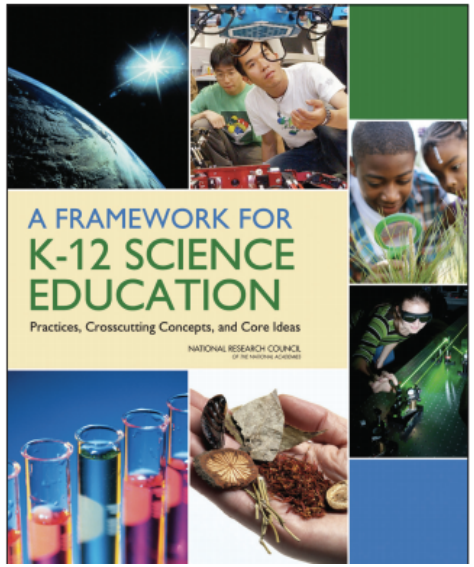
Policy Context

- Shift from separate standards for content and inquiry to integrated, three-dimensional view of science
- Elaboration of notion of inquiry, with sharper focus on practices that require intensive student participation in discourse



Learning Theory: Multiple Perspectives

- From Manz (in press):
  - Common definition across literatures: Argumentation as a social process of constructing, supporting, and critiquing claims for the purpose of developing shared knowledge
  - Existing approaches:
    - *Structure*: Focus on the structure of arguments and supporting students in adopting components of the structure
    - *Process:* Analyzes the nature of discourse moves to understand how students engage in convincing each other and developing knowledge
    - *Content-focused:* Characterizing whether students' arguments are scientific
- Our approach aligns most closely with *process* and *content* approaches identified in Manz' review

Challenge for Implementing Shifts

- Discontinuities are many and they are significant
  - Most discourse is teacher-directed and offers minimal opportunities for students to construct, critique, and defend claims with evidence (e.g., Newton, Driver, and Osborne, 1999)
  - Widely available curriculum materials provide few opportunities for sensemaking about investigations (Kesidou & Roseman, 2002).
  - Often isolated from scientific activity in the classroom, rather than emergent from grappling with uncertainty (Manz, in press).
- Wholesale transformations are challenging
  - New curriculum materials cannot be purchased anytime
  - Time allocated in districts for PD is limited (Banilower et al., 2013)
  - Teachers' repertoire for structuring productive discussions in science is limited (Driver et al., 2000)

Co-Design Strategy: *Focused Additions*

- Co-design with teachers provides one approach to aligning more with practices of scientific communities.
- Co-design:
  - Starts with a *flexible curricular target*
  - Does *not* seek transformation all at once
  - Targets specific aspects of teachers' practice with the aim of supporting *focused additions* to practice
  - The *additions* are focused to address fundamental challenges that are jointly negotiated

For more on co-design, see: Penuel, W. R., Roschelle, J., & Shechtman, N. (2007). The WHIRL co-design process: Participant experiences. *Research and Practice in Technology Enhanced Learning, 2*(1), 51-74.

PD Intervention: Contingent Pedagogies

- Collaboratively designed PD intervention
  - Developed in early phases of an ongoing research-practice partnership
- Fully integrated into an existing set of investigation-based curriculum materials adopted by district, *Investigating Earth Systems*
- Included a range of material supports and PD activities that extended over a year

PD Intervention: Contingent Pedagogies

- Initial Target:
  - Improving classroom assessment with interactive technologies
- Focused Addition:
  - Create classroom cultures where productive discussion of students' ideas can help develop students' thinking and reasoning
- Core challenge identified in the course of collaborative design:
  - Students' talk is directed to the teacher and falls flat quickly

PD Intervention: Contingent Pedagogies

- Key Materials
  - A set of questions to elicit student thinking, followed by a question to spark discussion, particularly student reasoning about their ideas
  - Classroom norms to use as a reference point and build a culture of productive discussion
  - "Talk moves" modeled after *Ready, Set, Science* examples (NRC, 2007)

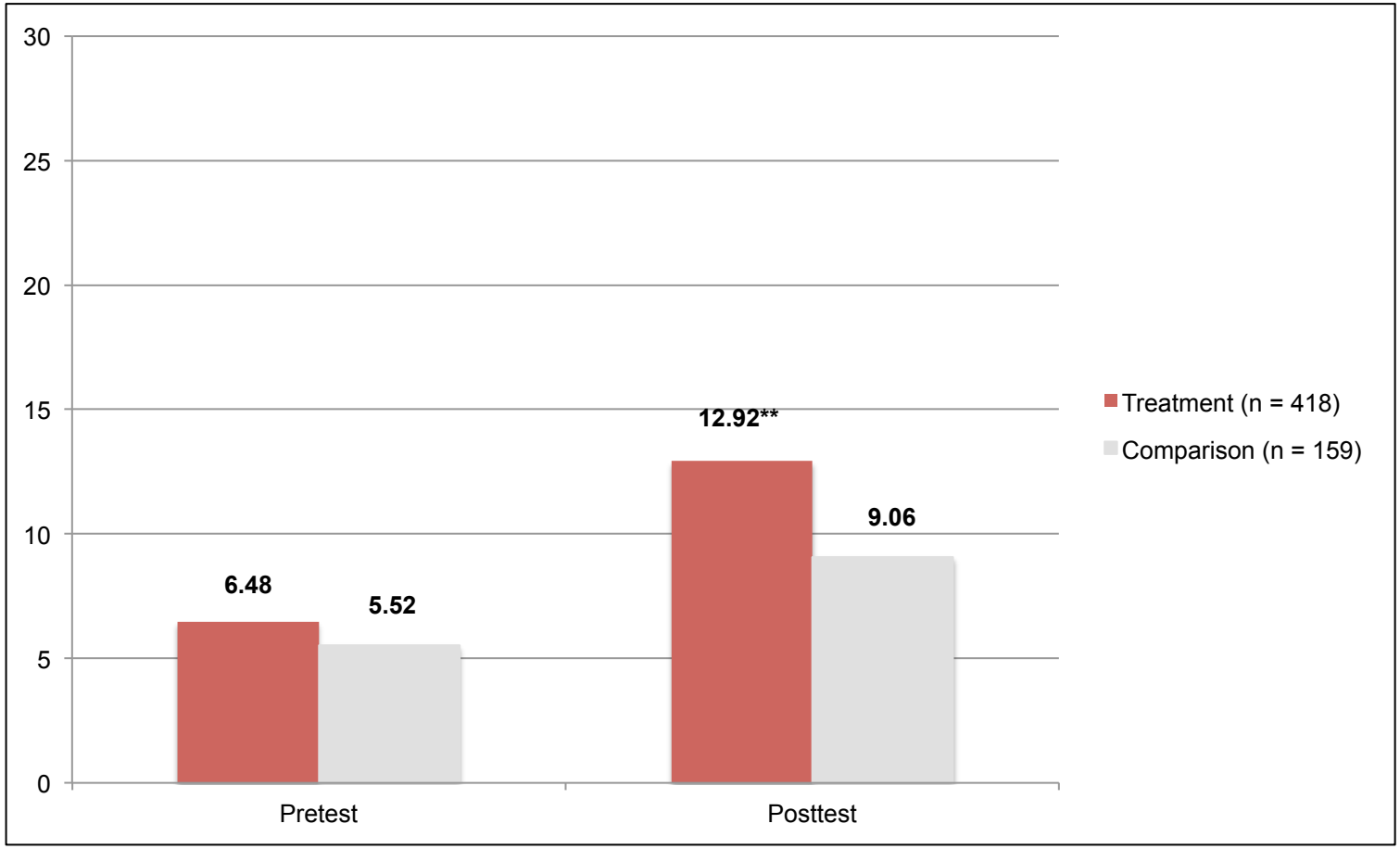
PD Intervention: Contingent Pedagogies

- Professional Development Activities
  - Two-day workshop where we modeled how to use norms and talk moves in classroom discussions
  - Classroom support from a teacher involved in co-design (co-implementation and technology support)
  - Regular teleconference check-ins to build community related to implementation and provide feedback
  - Email support to teachers with implementation guidance

Research Design

- Small quasi-experimental study: 13 teachers in treatment group, 6 in comparison group
- Student learning outcomes
  - Pre- and post-test focused mainly on core ideas, but with a few items to require students to evaluate evidence presented and make explicit connections to known scientific theories or models
- Teaching practices
  - Collected three videotaped lessons at specified points in investigation (beginning, end, and an unplanned activity)
  - Analyzed using coding scheme adapted from Inquiry Project

Student Learning Outcomes



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Argumentation Items

Item Number	Item Prompt (Without Images Presenting Evidence)
DP2-6	The images at right represent Earth's land masses over millions of years. The oldest view of Earth is labeled "1" followed by increasingly younger ones, until our current image of Earth, "4". Describe the changes on Earth's crust and what is happening below the crust to cause these changes.
D2-14	These two pictures show Mount Pinatubo, a large active volcano in the Philippines. Sam thinks the pictures were taken hundreds of years apart since Earth's surface looks so different in each picture. Ronaldo thinks the pictures could have been taken just days apart. Who is right? Explain your answer.

Scoring rubrics awarded more points for responses with an accurate claim that coordinated evidence presented with underlying theory or model.

Argumentation Items

	Contingent Pedagogies	Comparison	t (df)
DP2-6	M = 0.73 SD = 0.45	M = 0.64 SD = 0.48	1.91 (600)
DP2-14	M = 0.48 SD = 0.50	M = 0.38 SD = .49	2.09* (582)

Use of Selected Talk Moves to Promote Argumentation

Talk Move	Definition (Coding Guide)
Pose a **follow up question** to same student	The teacher asks questions that (are designed to) probe for the thinking that underlies a student's reasoning.
Invite students to **add on**	The teacher asks, "Who can add on?" to invite participation from anyone to join in and respond to or build on someone else's idea. This is not a request for restatement or repetition of a student's idea, but **a request for a response or addition to an idea**. In this move, the teacher is asking respondents to relate their comments to the current idea.
Invite students to **weigh different perspectives**	The teacher asks a question that asks students to consider an idea that is part of the discussion, put forward their perspective on the topic, note their agreement or disagreement, and explain why.

Analysis of Selected Talk Moves to Promote Argumentation

Condition		Weighing Perspectives		Adding On	
	Follow-Up Questions	Taken Up	Not Taken Up	Taken Up	Not Taken Up
Treatment (n = 12)	8	5	2	3	0
Comparison (n = 16)	4	1	0	0	0

One Example of Effective Integration

- Teacher begins the lesson with a review of each of the norms.
- The teacher poses a clicker question. She has students self-identify after answering, and for two out of the three questions she poses, she has students move to one part of the room and then explain their answers, one answer at a time.
- At several points, she emphasizes the need for evidence to support conclusions, and at one point even says, "Does anyone else have another opinion, no a claim that can be supported with evidence?"

Clicker Question

Pose the Question

Which of the following is a reason why the mantle moves? Be prepared to explain your answer using what you learned from the investigation.

a. Because the mantle floats on a layer of magma.

b. Because Earth itself is moving.

c. Because heat from Earth's core circulates through the mantle.

d. None of the above: the interior of Earth is solid and cannot move.

Answer choices reflect problematic facets of student thinking identified in earlier phase of research.

Moves to Support Argumentation

S: Why I think it's D is because all of the pressure, having looked at the questions, it didn't make sense to me. And then mantle can't change its shape, it's just like one ball around the whole core in the inside of the crust. So it can't change shape.

T: Let's listen here. S said the mantle cannot change shape, that it's a solid around the core. **Do we agree with that? Everybody.**

S: I disagree with S., because the Earth moves around the sun. Yeah, but, we're still in the same place in NA, in CO, even if we're going around the sun. We move thousands and thousands, but we're the same place on the Earth.

T: So you don't say that the Earth moving is different from the mantle moving. **So do you agree or stick with what you said earlier?**

S: I stick with what I said earlier.

T: **Do you have any reasoning, or evidence?**

S: Yeah, because I still don't think the mantle itself moves around, it needs help.

Moves to Support Argumentation

Pressing for how investigation evidence supports a claim

T: About the plates on the corn syrup. Does that support or not support A?

S: It does not support A, because that's the core's heat going up into the magma to the plates.

Encouraging students to engage with one another's ideas, pressing for evidence

T: You know I feel like S. is just talking to me, and I'm feeling like I want to discuss some of it with her, M., what do you think, she's said a couple of things, that the mantle doesn't move, and it's that way because cookie dough because it's made of a few things. And how can you speak up here, do you agree with her, dsagree? What do you think?

S: Disagree.

T: How come?

Conclusions and Implications

- Key Conclusions
  - Our PD intervention had modest but significant effects on learning
  - We saw variation in implementation of talk moves, but greater use relative to comparison teachers
  - Use of moves for a few teachers was fluidly integrated
- Implications for Supporting Implementation of NGSS
  - Focused additions to practice may lengthen the time it takes to shift practice.
  - Bigger transformations will require bigger investments in materials, especially to support improvisation to orchestrate productive discussion.
  - Need to attend to discontinuities between classroom scientific activity and practices in laboratories as we make shifts: shifting our PD goals.