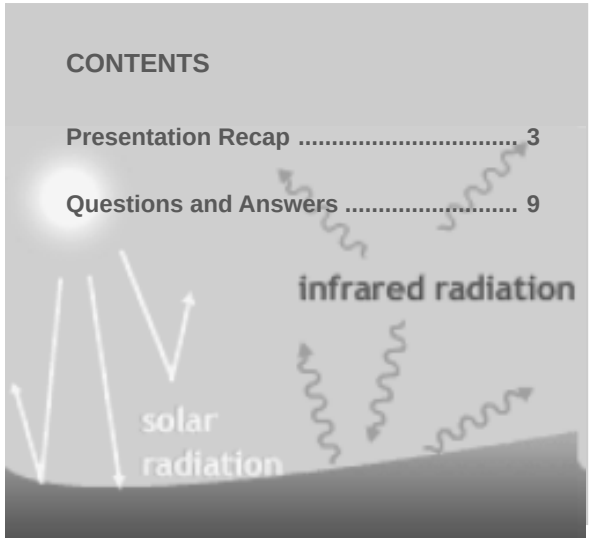
BREAKOUT SESSION

Sustainable Intellectual Growth of Elementary School Teachers in Science Content and in Science Pedagogical Content

CONTENTS

Presentation Recap 3

Questions and Answers 9



2009 Math and Science Partnership Learning Network Conference

Research Findings in Teacher Education: New Approaches → Transformative Possibilities?

January 25-26, 2009 • Washington, DC

TERC®

2067 Massachusetts Avenue

Cambridge Massachusetts 02140

617-547-0430

MSPnet

An electronic learning community for all MSP projects.

www.mspnet.org

NATIONAL SCIENCE FOUNDATION

This documentation is part of the **MSPnet** project, funded by the National Science Foundation and designed and facilitated by **TERC Inc.**, a not-for-profit education research and development organization based in Cambridge, Massachusetts.

Participant comments have been paraphrased; they are not exact quotes. The contents of this document do not necessarily reflect the views of TERC, the National Science Foundation, or the organizations of any participants.

MSPnet

An electronic learning community for all MSP projects.
www.mspnet.org

Principal Investigators
Joni_Falk@terc.edu
Brian_Drayton@terc.edu

Conference Documentation
Catherine McEver

About This Summary

This documentation of the 2009 Math and Science Partnership Learning Network Conference offers a brief summary of the presentations that took place during one conference breakout session and focuses on questions, answers and discussions during the session.

Readers interested in pursuing information about the project discussed in this breakout session are encouraged to visit MSPnet to access the full PowerPoint presentation. The abstract for this presentation is posted in the Virtual Poster Hall.

Cover: upper right, Judah Schwartz and Sue Doubler; other images are from presentation PowerPoint

Visit the MSP LNC 2009 Virtual Poster Hall

For all conference abstracts, as well as post-conference commentary and dialogues concerning the abstracts.

Visit MSPnet.org and click on Conferences or go to:

http://hub.mspnet.org/entry.cfm/msp_conf_2009_abstracts

SUSTAINABLE INTELLECTUAL GROWTH OF ELEMENTARY SCHOOL TEACHERS IN SCIENCE CONTENT AND IN SCIENCE PEDAGOGICAL CONTENT

Learning Network Conference Breakout
Session Number: 2 - 20

MSP Project:
Fulcrum Institute for Leadership in Science Education, Tufts University

An MSP Institute partnership to develop a series of hybrid courses in science for elementary and middle school teachers, primarily in high-needs districts, and to conduct research regarding how teachers make sense of new and subtle scientific ideas. The partnership is a collaboration between the Tufts departments of education and physics, TERC, and a number of public schools in the greater Boston area.

PI:
Judah L. Schwartz

Discipline:
Science

LNC Strand:
Other In-Service

Presenters:
Linda Beardsley, David Carraher, Claudette Fongkong-Mungal, Sara Lacy, Judah Schwartz, Roger Tobin

Presentation Recap

Judah Schwartz opens the session by outlining the five components of the forthcoming presentation: issues the project tried to explore; how they designed courses in response to those issues; how those courses were implemented; the effects on the partnership's understanding of student understanding and the behavior of teachers; and the potential future collaborations with other MSPs.

Roger Tobin begins by reviewing the challenges the project faced, including teacher fear and lack of confidence.

Some Challenges of K-8 Science Education

- Many teachers have minimal science/math background, lack confidence and comfort.
- Teachers themselves need greater competence and confidence.
- Range of science topics covered is enormous.
  - Impractical to try to teach all the necessary content.
  - But significant, challenging content is essential.
- Teachers are very busy.
  - Courses must fit their lives as well as their needs.

The starting point was the following hypothesis, which targets the teachers' own growth as a way of gaining leverage.

Hypothesis One:

To improve teachers' attitudes and practices:

- Target teachers' own intellectual growth.
- Focus on a few "big ideas" with wide applicability.
- Model effective processes of scientific investigation, scientific reasoning, scientific communication, and science pedagogy.

Tobin notes that while the "big ideas" involved relate to physics, one could easily imagine doing this from a biology or chemistry perspective. After much discussion and argument, the following list of "big ideas" was generated.

"Big Ideas"

Generative concepts with broad applicability:
- Particulate nature of matter
- Processes of energy transfer
- Equilibrium
- Measurement and modeling
- Generation, representation and interpretation of data

Engaging contexts:
- Density, floating and sinking
- Heating, cooling, melting
- Climate change

DVD Clip

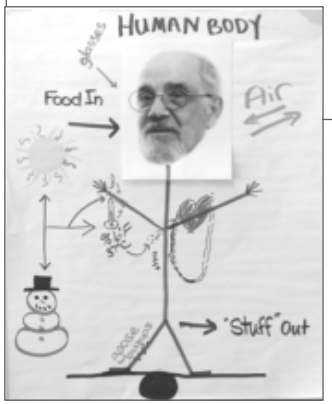
To illustrate, Tobin shows a DVD clip, "Improving Partial Understanding," depicting a discussion around the topic of equilibrium (Fulcrum Institute Science Working Group, May 19, 2008, Tufts, TERC).

Roger Tobin

Hypothesis Two

An effective program requires expertise and perspectives of:

- University science faculty
- Education researchers
- Cognitive psychologists
- Course developers



A second DVD clip, "Thinking Critically About Models," offers an example of the Science Working Group in session.

Generative concepts with broad applicability are communicated through activities conducted in engaging contexts, ultimately relating it by the end of the course to the whole issue of what determines the temperature of the earth, what that means, and where issue of global warming comes from.

Determining how to go about this led to hypothesis two and the formation of the Science Working Group, which worked to identify the "big ideas" as well as course content and activities to address those "big ideas." Each "big idea" comes up in a variety of contexts.

The Science Working Group

1) Includes
   - Scientists
   - Education researchers
   - Cognitive psychologists
   - Course developers
2) Meets monthly to:
   - Plan course content and activities
   - Clarify and refine key concepts and ideas (energy, radiation, equilibrium)
   - Discuss what is and isn't working, and what to do about it.
3) All participants bring essential knowledge and experience.

The third hypothesis deals with teachers becoming leaders as a result of this process.

Hypotheses Three

Through such a program teachers can become science education leaders in their schools, districts, and beyond.

Tobin turns the presentation over to Judah Schwartz to talk about how the project structured its courses in order to pursue its goals. One of the problems, Schwartz notes, is the time constraint on teacher availability to attend classes. "If you want to reach them, you have to reach them where they are and at times that are convenient to them," he observes. As a result, the bulk of the courses have been implemented online, which leads to another set of issues, Schwartz comments, particularly if you're committed to a pedagogical strategy that says that teachers have to investigate, probe and struggle for themselves in trying to understand things.

Susan Doubler discusses how the project addressed some of these issues. She notes that while these are online courses, most of the work takes place off-line, and adds, "A misunderstanding about online learning is that all of the learning has to take place online." She observes that while elements of the online environment are wonderful for supporting learning, the goal here was to have the teachers actually engage in science and to engage in understanding the pedagogical strategies and then implement the strategies. In addition, Doubler relates, the project's belief was that for teachers to be leaders, they first and foremost needed to be leaders in their classrooms. Teachers also needed the intellectual work around science to develop new understanding of the core concepts and big ideas and walk away understanding these ideas in great depth.

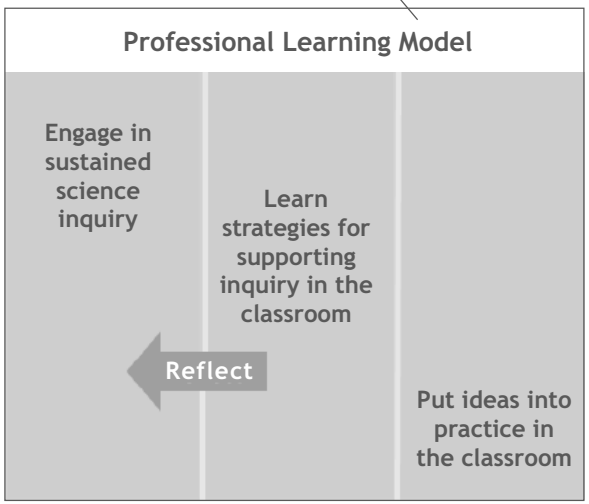
This translates to four courses offered by the Fulcrum Institute, which involve eighteen months of intensive study.

3 Online Courses
1 Face-to-Face Institute

- *Some of What Matters* ***About Matter***
  A semester-long online course focusing on matter at the macroscopic level
- ***The Summer Institute***
  A week-long session on campus focusing on matter at the microscopic level.
- *Conceptual Distinctions:*
  The Case of ***Heat and Temperature***
  Offered online in the fall
- ***Earth's Energy Balance***
  Online in the winter

There was a shift in language, Doubler notes, away from talking about professional development to talking about graduate level courses. The project is now very explicit about the expectation of intellectual growth. "The teachers are very ready to make that investment," Doubler observes, "and too often we don't ask that and don't provide something that is crafted to really engage them intellectually."

Underpinning all of the courses is a pedagogical model. The first component is to engage them in sustained science learning through inquiry. The second is to develop teaching strategies. The focus of the pedagogical learning is on formative assessment. "We believe it is one of the most powerful changes that they can make in their practice to improve student learning," Doubler reports. The third component involves putting the ideas into practice in the classroom.



While discussions of science and teaching take place separately there is still tremendous synergy, Doubler notes, and offers an example of this process from the Heat and Temperature course. Part of the teaching philosophy is that if teachers can listen carefully to their students' ideas, their teaching will change and they will become more responsive to their students. Some of the pedagogical sessions are designed to help teachers develop the skill of conducting clinical interviews. The classroom context is complex, so the sessions frequently begin with a situation that is less complex—in this case interviewing one student—so they can learn the skill and then use it in their classroom.

Sara Lacy continues the presentation, offering an overview of how the courses are structured. The courses are launched face-to-face and teachers then work online and at home. A

Example: The Case of Three Spoons

From the Heat and Temperature Course, after working with conduction, convection

The question is: How will heat be transferred from the cup of hot water to the spoons—one metal, one wood, one plastic?

One of the research team members interviews a third grader, posing this question, and the clinical interview is videotaped. The teachers analyze the tape. The research team member then conducts the same interview with a scientist so that the teachers can see how a scientist answers the question. The process began with pedagogy and circled back to the science, reinforcing the scientific ideas about heat and temperature. With this scaffolding and structuring, the teachers then conduct clinical interviews with one student from their classroom.

Learning Science Online and at Home

Sara Lacy

For more information regarding research on student understanding, contact:
David Carraher, Director of Research, Fulcrum Institute
david_carraher@terc.edu

session goes online every week. On Fridays they get an assignment that involves conducting hands-on investigations, working at home and conducting experiments with everyday objects and with hi-tech resources like heat probes.

Hands-on Investigations

- Investigations of everyday phenomena that engage adult learners
- Done with simple equipment at home
- Hi-tech resources

By Tuesday they have their results posted and work together in small, facilitated, online discussion groups.

Scientific Discussions

- Further understanding of science concepts and support scientific sense making
- Take place online in small study groups
- Are led by teacher participants
- Model productive classroom discussions

Another feature of the course is the research scientists who are on tap and participate frequently in the courses.

Research Scientists

- Model scientific thinking in online sessions
- Respond to weekly forum discussions
- Work with teachers in face-to-face sessions

Judah Schwartz explains that the project is engaged in two kinds of research. One is research on student understanding. For an overview of the second kind of research regarding findings on teachers' attitudes and behavior in the classroom, he turns the presentation over to Claudette Fongkong-Mungal from the Intercultural Center for Research in Education (INCRE), which served as outside evaluator.

Fongkong-Mungal offers an overview, noting that most of the work done involved qualitative research. The evaluation looks at three cohorts, the third of which is currently in progress.

The INCRE Evaluation

What did the observation and survey data show?

Cohort 1: January 2005- June 2006

Cohort 2: January 2007- June 2008

Cohort 3: January 2009- June 2010

The second column below indicates the number of teachers starting/completing the program. Fongkong-Mungal refers back to Susan Doubler's statement regarding the expectation of intellectual growth and notes that teachers in the first cohort were thinking it was like any other program and weren't anticipating the time required.

INCRE Evaluation

	# Teachers	#Schs/Dist
Cohort 1	35/25	12/6
Cohort 2	33/29	21/15
Cohort 3	56/?	31/20

Fongkong-Mungal then focuses on Cohort Two to offer a sense of the type of information being collected.

The INCRE Evaluation

What did the observation and survey data show?

Cohort 2: January 2007- June 2008
29 pre-K-8 Teachers
21 schools in
Eastern and Central Massachusetts

Evaluation involved three different activities.

INCRE Evaluation- Data /Instruments Used

- Science Class Observations — RTOP & INCRE Protocol
- Face-to-face interviews — INCRE protocol
- Mail-in survey — INCRE & FI protocol

For Cohort Two the mail-in survey had a 72% return rate. Before sharing the findings, Fongkong-Mungal refers back to one of the initial hypotheses.

INCRE Evaluation

Teachers' attitudes and practices can be greatly improved through a limited set of highly interactive courses targeted on the teachers' intellectual growth, focused on a few "big ideas" and aimed at modeling effective processes of scientific investigation, scientific reasoning, scientific communication, and science pedagogy.

Results from the mail-in survey, with 21 of 29 teachers responding, reported that participation in Fulcrum deepened their understanding of both content and pedagogy.

Teachers indicated that participation in the Fulcrum Institute also changed the way they taught.

INCRE Evaluation- Claims made

Teachers reported that participation in the FI changed their ***classroom practice***

- Changed the way I teach science- 95%
- Resulted in more inquiry science in my classroom- 86%
- Increased my confidence to facilitate student group investigations- 86%
- Helped me to design classes based on students' scientific ideas and questions- 81%

These are results from the classroom observations of the teachers, with data on 23 of the 29 teachers. More teachers encouraged their students to share their ideas, generate conjectures, actively participate, and work collaboratively with peers. In addition, more teachers provided activities for their students that required them to think more deeply.

INCRE Evaluation- Claims made

Teachers reported that participation in the FI deepened their understanding of both ***content*** and ***pedagogy***

CONTENT
- Properties of matter (Course 1)- 100%
- Energy transfer (Course 2)- 100%
- Equilibrium (Course 3)- 95%
- Student misperceptions in science- 100%
- The role of Math in building scientific explanations- 76%

PEDAGOGY
- How to use inquiry approaches in my teaching- 100%
- How to facilitate student discussions about science- 95%
- How to use formative assessment to shape my teaching- 95%

INCRE Evaluation- Claims made

Observed Positive change in Teacher practice

Cohort 2 (n=23)	Mean rating		
Teachers encouraged their students to:	2007	2008	% Change
• Share their ideas	1.30	1.83	+41%
• Generate conjectures	1.09	1.43	+31%
• Actively partic.	2.43	2.91	+20%
•Work collaboratively with peers	2.83	3.30	+17%
Teachers provided thought-provoking activities for students	1.65	1.91	+16%

8 Sustainable Intellectual Growth of Elementary School Teachers

One-on-one interviews involving all 29 teachers indicate teachers rate both their own and their students' interest and engagement in science higher than their science understanding and skills. Fongkong-Mungal notes that in the follow-up data for teachers, while interest and engagement remain high and self-rating of science skills has improved, the teachers have lowered their rating of their scientific understanding. The assumption is that they now know enough to realize how much they don't know.

After going through Fulcrum, teachers also lowered their estimation of students' understanding and skills, realizing that students didn't know as much as they had first thought.

Fongkong-Mungal directs attention back to another original hypothesis and points to a quote from the mail-in survey data. This is from a sixth grade teacher who had just started teaching. Fongkong-Mungal notes that more teachers reported that they were leaders at the classroom level. For example, they invited other teachers to come into their classroom to see them teach, or they reported that at the grade level team meetings there was more discussion about discovery. However, there was less reporting that they were now team teaching with other teachers.

Fongkong-Mungal observes that during another breakout session at the LNC, the presenters were talking in terms of inoculations and boosters. Using that analogy, she identifies Fulcrum as the inoculation and the booster as the networking that these teachers manage to set up. The number of teachers within a district

INCRE Evaluation- Claims made

In interviews teachers' ratings of their ***interest*** *and* ***engagement*** in science have been higher than ratings of their ***science understanding*** *and* ***skills***

TEACHERS N=29	Interest	Engagement	Understanding	Skills
Baseline	97%	93%	93%	83%
Follow-up	96%	97%	90%	93%

INCRE Evaluation- Claims made

In interviews teachers also rated their **students**' *interest and engagement* in science higher than their *science understanding and skills*

STUDENTS	Interest	Engagement	Understanding	Skills
Baseline	86%	79%	55%	55%
Follow-up	90%	83%	48%	48%

INCRE Evaluation- Claims made

As a result of participation in the FI teachers can become science education leaders in their schools, districts, and beyond.

"Fulcrum makes me want to be a science leader…I now give suggestions and tips to my grade team about ways to teach and questions to ask. If I had not had Fulcrum then I don't think I would have the confidence to put my two cents in, especially being new in the school and the only female [science] teacher." - Grade 6 teacher

INCRE Evaluation- Claims made

Teacher Leadership

- 76% of the Teachers reported that participation in the FI helped them to become a science leader in their school.
- 67% reported that participation in the FI resulted in greater support for inquiry-based learning in their school.
- More teachers reported science leadership at a personal or peer level rather than at the broader school or district levels.

INCRE Evaluation

Finally…

The impact of the FI continues…

"Many times professional development ends when the last session meets. The Fulcrum Institute continues to make me feel supported." Grade 4 Teacher

Since completing the FI in June 2008, 90% of the Cohort 2 teachers

- Continue to use FI materials/information themselves
- Continue to share FI materials/information with colleagues

95% of the Cohort 2 teachers recommended the FI to their colleagues

who have attended Fulcrum is increasing, she notes, and adds that this is the only way that the teachers will be able to change what happens over time inside their districts.

For further information contact:

Dr. John Zuman
Intercultural Center for Research in Education
366 Massachusetts Avenue
Arlington, MA 02474

jzuman@incre.org

Judah Schwartz identifies another way of presenting the impact of Fulcrum on teachers, and that is listening to the teachers themselves. Linda Beardsley, Director of Teacher Education at Tufts, introduces a video of teachers who have completed the Fulcrum Institute courses and asks breakout session participants to think of a phrase or image that comes to them while watching. She then shows the video, "Changing Lives of Teachers, Fulcrum Institute, Tufts University, 2008. Participants respond to the viewing with words that include "excitement," revolutionary," "communication."

Beardsley notes that it is the talking to each other that is revolutionary, and reports that one thing that has happened as the result of the university being involved is that the university is now widening its way of communicating—with the schools, with the preservice program, between arts and science and education faculties, and between administrators. "It is those webs of communication, talking to one another, crossing those boundaries that we arbitrarily establish when we think about changing practice, changing content knowledge," Beardsley says. "I think in the end it really is thinking about teaching as intellectual work; teaching as sharing and learning and the intellectual component of that."

Questions and Answers

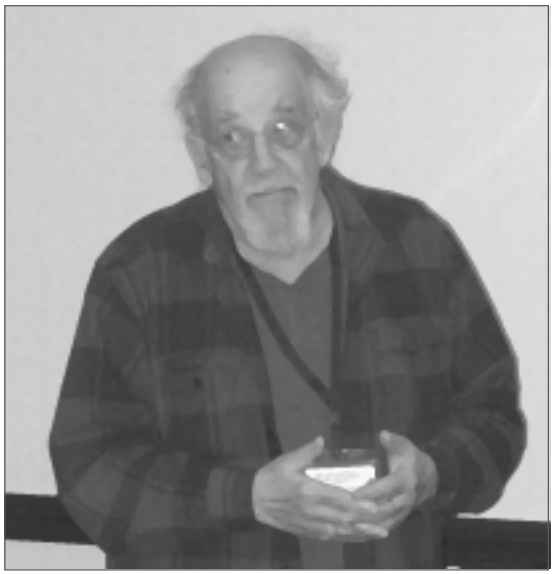
A Flaw in Middle School Science: From Inductive to Deductive

- One of the things that I've noticed about the standards in the state of Pennsylvania might be at the root of the science instruction in middle school. There's a very conscious presentation of science and inquiry in elementary school in grade six and below. It's very inductive. Then the standards suddenly slam people with the idea that the first step of the scientific method is statement of the problem. That's very deductive and authority based. It appears as though you've got some data that could really go after that transition being inappropriate. • Participant
- It's a sneak attack. We say to teachers at the very beginning and as often as we can, these courses are not primarily designed to help you on Monday morning. They're to help your growth. They're to help you as an adult learner. They're to help you as an intellectual. We believe you will do better in whatever you do if you continue to grow as an

Linda Beardsley

A Desire to Share with Other MSPs

One of the things that Fulcrum would love to do is share with other MSPs some of the ways we've devised for developing materials, sharing materials, implementing courses, and engaging teachers. We want to go beyond the usual notions of professional development. We really want to stress that the important issue is to rejuvenate the teachers intellectually, to get them to think of themselves as scientists. If you or your MSP is interested in collaborating, in working with us in some way or other, we're open to negotiating any way that seems to make sense to you. • Judah Schwartz



Judah Schwartz

intellectual. It's not a methods course. It's not, "How do you work this unit or that unit?" And that's terribly important.

In our first cohort there was enough miscommunication that some teachers thought they were going to get Monday morning stuff. I think that accounts for the relatively large dropout in the first cohort. But as it became clear that's not what we are about, I think teachers first of all became much more conscious of what they were buying into. They typically spend anywhere between six to twelve hours a week on this for eighteen months. That's not Wednesday afternoon PD, so they're serious about this. Does that answer your question? • Judah Schwartz

- Part of my question is about the Monday morning thing. The other part is, there's a real structural flaw in middle school science that's not just about how a teacher is going to cope with this flaw. There needs to be a rethinking about how middle school science is presented with much more authentic voice. • Participant
- Right. You're not going to get an argument from me. • Judah Schwartz

A Multidisciplinary Perspective

- I wonder if what I was thinking at the very beginning, when you presented your panel, sort of relates to all of this. You had a cognitive psychologist, right? This is very curious to me because very rarely do you see someone who knows anything about how we develop or about how kids develop. I commend you on that because my guess is, that person can contribute certain things about development in general, aside from content, that leads to preparedness or lack of preparedness. • Participant
- As Roger stressed, there really is a confluence of a number of different disciplinary perspectives. They're all needed and they complement one another. No single disciplinary perspective in my view is sufficient. • Judah Schwartz

A Community of Learners

- I would add that when our group meets, we're intellectually challenged too, so it's not just the teachers. It's intellectually interesting and challenging for us. • Sue Doubler
- I'll give you a lovely incident. Forty-eight hours ago, we were in the middle of a workshop with the new cohort. They were developing benchmarks for mass and volume and weighing things. So okay, how much does a cell phone weigh? One of the cell phones goes off and starts ringing. The following question came up, which I'll let you ponder: Does a cell phone weigh more when it's ringing? It's not a trivial question. That kind of thing, much to the consternation of our program manager, who tries to keep us on topic, is what constantly comes up. It's a community of learners. The team is itself a community of learners. • Judah Schwartz

- So is that how you break down barriers? I was thinking that in our own state MSP, we have a lot of ivory tower warfare going on where the teachers are feeling uncomfortable. Do you guys have a strategy for that, or is it just that you guys are really good people? • Participant

- It's called creative tension. It's really helpful and has been a wonderful thing, in part because everybody's got something to say. • Sara Lacy

- Nobody's timid. • Judah Schwartz

Tracking Teacher Content Gain via Growth of Online Discussions

- Are you charting or documenting teacher content gain? • Participant

- We can document teacher content gain. One of the nice things about online courses is that they are self-archiving. We have reams of data about the growth of teacher discussions. So there are teacher content gains. What I'm hoping for is that there will be an army of doctoral students who will do discourse analysis on this growth of teacher discussion, but there is no question that there are teacher content gains, and that's where the data lie. They do not lie in the formal testing of teachers. They do lie in the online sessions.

  We've given a lot of thought to the structure of the online weekly sessions. There are challenges. You can watch the growth of response to the challenges. They've learned about density and they've mucked around with measuring various hunks of aluminum and so on. They you say, "The newspaper has this graph of population density. Where's the mass and where's the value there?" You see if they can take what they've learned—it's called a transfer experiment, right? Except it's not per volume and it's now per area, but it's the general notion: let me look at an intensive quantity, namely a measure *per* measure.

  So there are a lot of ways we try to get at teacher gains that I think are generally a lot more sophisticated than the kinds of instruments that are normally used. • Judah Schwartz

Teachers Listening for Student Perceptions

- Would your teachers agree that they see themselves as researchers into their students' learning? • Participant

- I hope so. Certainly we spend a lot of time during the course of the three semesters helping them learn how to listen and respect the fact that there is subtlety in students' responses. The spoon experiment is very interesting. One fourth grade student, during a taped interview with a teacher, said, "Well, there are cold waves and they move up the metal spoon." You've got to listen for that. You've got to hear that. If you become sensitive to listening for that, then you've gone a long way.

Teacher Realization of What They Don't Know

- In your evaluation of teachers' self-ratings of their understanding of science before and after Fulcrum, it went from a pre of 93% to a post of 90%. That doesn't surprise me. I wouldn't have been surprised if it had gone down to something like 40% when they realize that they never understood some aspect of science in the way that you're talking about it. Are you getting any of this, where they're so struck that they realize that they're in a different world, and then go back and change their behavior? • Participant

- You have to be careful. What you don't want to have happen is people walking away from this saying, gee, I don't know anything about quantum field theory. That's not what you're trying to do. What you're trying to do is get them to the point where they feel confident that they can think their way out of a box, so to speak, with the body of phenomena that they are confronted with, and to realize that there is probably more subtlety that they probably haven't engaged.

  As Roger pointed out, we can't do it all, but what we want to do is change their willingness to use what they understand to think through what they're confronted with, to recognize what they don't understand, to recognize that there are always subtleties. I think that's as much as we can do. • Judah Schwartz