Learning the discourse of inquiry: how in-service high school science teachers come to understand themselves as listeners. Lessons from Samantha.

Victoria Deneroff, William A. Sandoval, Megan L. Franke
University of California, Los Angeles
{vdenerof, sandoval, mfranke}@ucla.edu

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Introduction

Do you like using inquiry? I asked the rambunctious fourth period class. Several Yeah's. [Pause.] What would happen if Ms. Hill went back to teaching traditionally?
I'd go back to sleep. – Terrence, African-American 10th grader

On a Sunday morning last July, seven people – five urban high school science teachers, my friend Irene, former science resource teacher who now works for the University, and myself, former science teacher and now graduate student researcher – sat around a table overlooking the pool at the Lion Square Inn in Vail, Colorado on a glorious morning. We knew each other pretty well. We had all been involved in a five-year reform effort in the Urban Unified School District. As we sat in the Rocky Mountain sunshine, we knew that funding had dried up because no one would sign the grant renewal application, the third superintendent in three years was not interested in science, and everything we had worked for so hard was in jeopardy. The workshop facilitator had given us instructions about what aspect of inquiry we should be talking about. Irene started off, So, do we even want to do this? We all sat numbly, looking at each other. Finally Tammy said, I can't go back. Tears came to Irene's eyes. We went around the table and each person reaffirmed her/his commitment to using activity-based instruction in manner reminiscent of a religious revival.

Even though our understandings of inquiry might differ substantially, each of us identified so completely as reform teachers that returning to traditional practice felt utterly impossible. The irony is that no one besides Irene and myself really understood that inquiry is much more than what teachers commonly call "hands-on" science (Wells, 1999). Irene had invited us to the National Academy of Curriculum Leadership (NACL) basically because she had the funding and was grasping at straws trying to keep afloat a now struggling, previously flourishing reform movement. Still, the depth of feeling, including my own, revealed at this meeting took me by surprise.

We all came to hold this identity over the course of several years. One way or another

each of us heard about inquiry science teaching, myself in graduate school, some in teacher education classes, some in workshops, some from other teachers. In truth, the sophistication of our understandings varied significantly. Jesse had survived his first year of teaching on an emergency credential and had been following the suggestions of his mentor that he use hands-on activities. Samantha confessed to not knowing the definition of inquiry, although she had been using activities for the last several of her 25 years in the classroom. Tammy's students performed water quality and environmental monitoring studies outside of the classroom and had been a major factor in the community's defeat of a plan to build a power plant in the middle of an urban park, but she always referred to her practice as hands-on rather than inquiry. None of the teachers besides myself had deliberately and consciously aligned themselves as inquiry practitioners, and I was now out of the classroom. All of us had had the experience of watching our students go to sleep in our classes, and all of us struggled to find ways to change our teaching so that the lights in kids' eyes went back on.

In Colorado we devised a plan to pilot a tenth-grade inquiry science course called Science and Sustainability (SEPUP, 2000), realizing that other teachers would be need to be brought on board. Knowing that meaningful implementation of any reform curriculum was problematic, we joined forces with an ongoing research/professional development project at UCLA, Beyond Final Form Science (BFFS).

Inquiry as discourse. Learning to use inquiry requires a major shift for high school science teachers. In brief, the hallmark of the inquiry classroom is the authentic dialog about scientific ideas and processes that occurs between students and teacher and among students themselves (Hammer, 2000; White & Frederiksen, 2000; Roth, 1993; Calabrese-Barton, 1998; Warren & Rosebery, 1996; Hunt & Minstrell, 1994; Brown & Campione, 1998). The teacher's talk in an inquiry classroom is quite different from that of teachers who use the traditional IRE

format of interrogation, student response and teacher evaluation which dominates American science classrooms (Lemke, 1990; Cuban, 1993).

Much has been written about kinds of questions science teachers ask, but very little about how they interpret and understand students' responses (with the exception of Hammer, 1997; 2000). Teachers in inquiry classroom *listen to* students in order understand their reasoning. It is well documented that teachers using inquiry with some relative frequency ask questions to which they don't know the answer, for instance, asking students to provide evidence for claims (Wells, 1999). While the answers to such questions assist the teacher in understanding the students' conceptual development, the mere asking implicitly places value and importance on science as an intellectual pursuit, a subject about which the classroom community can reason and have opinions.

In traditional classrooms the predominant IRF (teacher *i*nterrogation, student *r*esponse, teacher *f*ollow-up) script requires the teacher to *listen for* the correct answer in order to validate it. When using such a participation structure, teachers rarely go much beyond factual questions (Lemke, 1991); certainly they almost never listen to understand what students *mean* by or *understand* about their correct or incorrect responses. Wells (1999), defending IRF as not in and of itself harmful, describes examples where a teacher follows up to probe and deepen her students' understanding (pp. 186-8). However, as practiced in American science classrooms, the IRF script impedes the process of inquiry. Researchers repeatedly report science teachers to be surprised by the persistence of students' alternative conceptions in spite of instruction (review article, Wandersee, Mintzes & Novak, 1994); given the participation structures found in science classrooms, this is actually quite predictable (Lemke, 1991; Cuban, 1993; Goodlad, 1984). Students know they are expected to produce the appropriate vocabulary appropriately used. Students who are asked "why" an answer is correct generally assume their answer was wrong

and change it (Franke, personal communication, 2000). Question-asking in traditional science classes often degenerates into a "guessing game" as students compete for the prize of approval when they come up with the answer the teacher was thinking of.

The teachers in our study had persistent difficulties in understanding inquiry as discourse. We believe much of this arises, at least in part, from cultural norms of teacher identity. Students, parents, administrators and teachers themselves believe that the teacher's role is to oversee the acquisition of scientifically correct information, be it facts or concepts. Teachers believe that they must correct wrong answers, that students cannot leave the room with wrong ideas (Talbert, 1992). Paradoxically, because their teachers do not probe for students' ideas, students in traditional science classrooms are *more* likely to retain alternative conceptions of scientific concepts.

This paper explores the struggle of one teacher as she tries to learn and apply the discursive practices of inquiry in her urban high school science classroom. We specifically concentrate on her attempts to *listen to* student thinking and her emergent ability to incorporate this discourse into her teaching practice and how this might reflect a change in her identity.

Theoretical Framework

Discourse and science education reform. In designing our professional development, we were acutely aware that the mere fact that a workshop encourages teachers to use inquiry does not make it so. Dr. Herbert Thier, the head of the S&S project, says to teachers, "S&S is a course. The curriculum is what happens in your classroom" (Personal communication, July, 1997). In fact, if there is any lesson to be learned from 50 years of research on school reform, it is that teachers most often adapt new pedagogies and curricula in ways that make them indistinguishable from traditional classroom practice. Sarason (1996) identifies discourse as the heart of reform:

> What I am saying here I said in the book but, I have since concluded, I did not sufficiently emphasize how bedrock the asker-answerer relationship is for school change. Any effort at systemic reform that does not give top priority to altering that relationship will not improve educational outcomes. Since I wrote the book [1971] I know of no evidence disconfirming that assertion. You can seek to change this or that aspect of the existing system, but unless those changes directly or indirectly change the student-teacher relationship, classroom learning will be unproductive, i.e., children will "learn" but it will not be learning that has personal and motivational significance for the learner (p. 367).

Bearing in mind our conviction that the "failure" of school science reform since the 1960's lies in its neglect of classroom talk, the focus of our professional development project is on the specific discursive practices classroom inquiry requires. In previous work (Sandoval et al., 1999), our research group has found that teachers' discourse practices in "inquiry" classrooms can actually preclude genuine inquiry.

David Hammer (1997; 2000) analyzes teachers' talk during professional development meetings on physics teaching. He has characterized teacher discourse as a "language of action" (2000, p. 200) rather than reflection. Teachers in his workshops appear to understand students' thinking in terms of appropriate teacher actions in particular classroom situations; they seem to have great difficulty making explicit epistemological or conceptual connections. Our own analysis of teachers' talk about teaching confirms and extends this observation (Deneroff et al., 2002).

The forces which resist change are powerfully embedded in the school context, including the reifications of teacher identity held by students. We interpret the Samantha's commitment to reform to be also an identity, a part of her own understanding of who she is and what she believes in. We argue that an identity as an inquiry teacher is vital for teachers who go "against the grain" (Cochran-Smith, 1991).

Sociocultural theory. In order to both design professional development and interpret its results, we have used the theories of situated cognition developed by Lave and Wenger (1991).

Starting from a definition of learning as change in participation over time, we have sought to induce a change in teachers' social participation, both in and out of the classroom.

Wenger (1998) conceptualizes a social theory of learning which includes four dimensions:

> a. Meaning: a way of talking about our (changing) ability – individually and collectively – to experience our life and the world as meaningful.
> b. Practice: a way of talking about the shared historical and social resources, frameworks, and perspectives that can sustain mutual engagement in action.
> c. Community: a way of talking about the social configurations in which our enterprises are defined as worth pursuing and our participation is recognizable as competence.
> d. Identity: a way of talking about how learning changes who we are and creates personal histories of becoming in the context of our communities (p. 5)

Wenger's construct of identity is an important insight into learning in communities. As growth occurs, members of the community assume new identities following individual trajectories from peripheral to full participation. Furthermore, established identities within communities of practice become difficult to change as they become reified. In this instance, the identity of the teacher as expert and source of most or all knowledge in the classroom is a cultural artifact that has become a powerful organizing principle of schools, a self-concept which is not easily discarded. For a teacher to use inquiry because educational researchers say she should instead function as a coach is not simple: In addition to disassembling her own identity as knower to rebuild it as facilitator, she must contend with the reifications of the teacher identity held by students, administrators and parents. From this perspective, teachers' puzzling resistance to the changes required by switching to inquiry pedagogy, demonstrated by many researchers to be more epistemologically aligned with the way students learn, becomes more rational.

Identity. Support for the understanding of learning as a change in identity comes from a 1991 study by Cain (1991), in which she studied the way drinkers come to identify themselves as

alcoholic and members of Alcoholics Anonymous. She proposes a two-stage process: "dissolution" of the old identity as someone with problems who could drink normally and "acquisition" of a new identity as alcoholic and therefore unable to drink as others do (p. 218). This model of dissolution-acquisition provides a way to understand how identity changes over time.

Cain uses alcoholics' stories as a way to understand the trajectory from newcomer to old-timer in AA. In a similar way, We believe teachers' stories can provide evidence of changing identity. In some ways, we think the identity construct is a slippery slope. Asking people how they identify themselves probably has limited value – they are likely to censor themselves heavily. On the other hand, asking others about someone else's identity is fraught with peril, as it is fairly impossible for another person to make that judgment. Still, identity is an important dimension of the community of practice model, and we use it in this limited, non-psychological sense. We believe that indicators of a change in identity over time, such as stories people tell, or the kind of talk that happens in professional development and in the classroom, are valuable ways to assess teacher learning.

Method

In this paper we use qualitative analysis to understand how a subset of one teacher makes sense of a year-long professional development project, "Beyond Final Form Science" or BFFS, on high school science teaching. After the meeting of NACL in Colorado in July 2001, she became a voluntary participant in our year-long study of 20 teachers, aimed at understanding how professional development can support their use of inquiry. In addition to participating in BFFS, all use an NSF-funded integrated science course, "Science & Sustainability" (S&S) which is billed as being an "inquiry curriculum" (SEPUP, 2000).

For the present paper we analyzed approximately 19 hours of videotape using the video

microethnography protocols developed by Erickson and Shultz (1991). Concentrating on a few episodes, we have been careful to verify that these were typical of the conversation that occurred during taping, and noting instances that were atypical. Additionally, we have audiotape interviews with Ms. Hill, observed her in the classroom for 8 hours, on a field trip for approximately 2 more hours, and then audiotaped her comments as she watched an hour of video of her own teaching. We have chosen to examine specific instances of discourse as they occur in the project meetings, interviews and classroom observation with the following questions in mind:

A. What is Samantha's trajectory as regards *listening to* students' thinking about scientific concepts. Can we infer a change in her identity as a listener and teacher?

B. What can we learn about professional development by analyzing discourse? Can we get beyond declaring successful a workshop which is "liked" by the participants?

Data Analysis

One of the 5 teachers who went to Vail last summer, Mrs. Hill is a 25-year veteran who has taught at 22 years at Lamarck High School. Test scores at Lamarck, which is situated in an economically depressed community, serving African-American and Latino students exclusively, are low enough for it to be on a list of 10 worst high schools in the District. Mrs. Hill admits to being burned out and ready to quit a few years ago. She attributes her renewal to getting involved in the District's 5-year, NSF-funded professional development project.

Prior to participating in BFFS, Samantha had a strong identity as a "hands-on" science teacher. Following are excerpts from an interview taken in November (after two BFFS project meetings).

Text	Annotations

I was the only person at my school, and at first I went just to get free stuff, and to be able to trade ideas with other people, but once I started doing the hands on stuff, it really renovated my teaching and made it a lot more relevant for the kids. [It's] a lot more work for me, because it's a lot harder to teach inquiry and do hands on stuff than it is to teach traditional text book stuff, but I actually went home at the end of the day physically tired but mentally rejuvenated, because I saw kids who were getting excited about learning.	Samantha became involved with reform not really knowing what it was about. She was looking for a way to get some materials for her classroom as well as relief from the isolation she felt at her school. As she made a transition from traditional to hands-on instruction, the response of her students prompted her to become involved further.

Samantha reflects on being a different kind of teacher in a way that shows she is very much aware of the reified identity of science teacher. Teaching conceptually has led her to change her mind about what makes a good teacher. Comments here and elsewhere, however, show that she is mindful that her stance runs counter to the prevailing norm.

When they started learning concepts instead of memorizing stuff, they just learned better and they made connections better. And so it's, it's always exciting to see somebody who learns something or discovers something and to see the look on their face, or to ask a kid to give you an answer to something, and they can actually do it, and just the look they feel for being able to come up with an answer that, you know, is acceptable, that they didn't have to memorize, so they are not sitting there with their eyes rolling around the head going "Oh God, oh God, oh God, what is that definition?" But you can let them make up their own or explain a concept and … like the kids today, with the heat. They never really told me what heat was but they have a pretty good understanding of what it is, and there are people who graduate... There are science teachers who don't even know what heat is. So I've liked this, because I've actually learned and understood some things better than I've ever did when I really supposedly learned them and became this, you know, science guru.	Samantha has noticed that teaching conceptually creates a different discourse in the classroom. She interprets a classroom discussion about thermodynamics occurring earlier that day as revealing students' genuine understanding of heat transfer and heat capacity. She compares this favorably to the knowledge of many college graduates and even science teachers. In the course of teaching about heat, she has learned herself. She makes fun of herself as an authority figure in the classroom, and implicitly compares her current identity with traditional notions of what it means to be a science teacher. In BFFS meetings, we have attempted to challenge such vague statements as, I know that 'They (the students) know it, even if they can't express it.' This has proven to be extremely difficult.

In a November interview, Samantha has not resolved the issue of content knowledge versus depth of understanding. The primacy of subject matter constitutes a fundamental norm of high school teaching (McLaughlin, 1993). Her instinct that students get more out of conceptual teaching runs counter to her previously-established identity as a high school teacher. In order to use inquiry in the classroom she must continue to strengthen her identity as an innovative, reform-minded high school science teacher. The difficulty she has articulating to herself and the interviewer exactly what it means to use inquiry in the classroom makes this transition problematic for her.

I'm not sure that I have a crystal clear, a hundred percent understanding of what inquiry is, myself. And then the problem I have with trying to teach inquiry to kids is, if it's something I don't really understand, and I'm a lot more flexible and have a lot more experiences and stuff than them, how do I get them to discover what it, what it is, without giving them too many prompts so that I take away the inquiry?	In spite of her observations about the change in classroom talk brought about by using inquiry, Samantha has not adopted our (professional developers') notion that inquiry actually *is* a particular kind of discourse. There is an underlying assumption here, related to Lemke's construct of "objectification of evidence," (Lemke, 1990) that scientific concepts are inherent properties of materials to be discovered by observation rather than socially constructed explanations for the way materials behave.

When we explicitly talked about how she asks questions in the classroom, Samantha indicated that she is consciously changing her discursive practice. Still, her criteria for what constitutes student understanding remain somewhat unformed.

Sometimes my question back to them is "What else now?" I do that a lot more than I used to. Or, "Why do you think that?" Like that whole thing today about... The kids were trying to explain that it was thinner, and then all of a sudden they...were grappling with the word, a scientific word for thinner, and I thought maybe they were going to talk about maybe viscosity a little bit, but then they did density, which was fine too. So, that was kind of cool...because we did density in Integrated 1 [the previous year's science class] ... and we talked about it a little bit this year, because we were talking about wind and what makes wind. But I was amazed when they – I actually kind of felt like this little tingle of joy inside like, "Wow, where did they come up with that?...I'm just kind of sitting there like, "Are those my kids?" but it shows you that they are thinking, it's just pretty incredible, pretty cool."	Samantha is proud that her students are able to use scientific language when discussing the thermodynamics question she posed to them. She appears to be *listening to* students' conceptual understanding, and values student thinking as a goal of learning. Samantha asked the students which had more heat, 1 liter of water heated for 5 minutes to 20_, or 1 liter of alcohol heated for 5 minutes to 50_. The students had argued the alcohol held more, because it was less dense and therefore had more 'space' for the heat. Samantha knew this was a misconception, but was excited that the students had been able to use vocabulary and concepts from their previous year's course. In light of her previous experience, that students forget memorized science 'facts' quickly, this episode is an important confirmation of the methods she is using.

As professional developers and researchers, we find inquiry as it plays out in her classroom incomplete. Students' appropriation of scientific vocabulary is one part of conceptual

learning about science, but appears to be an impoverished understanding. This seems to be a common denominator among the teachers in our study. In analyzing the professional development videotape, we have identified several instances where teachers accept students' use of vocabulary as evidence of conceptual understanding. We are beginning to see it as a basic obstacle to teachers' understanding inquiry. The most explicit example comes from another teacher, Ms. Bird, during a workshop that looked at students' ideas about ecology.

Ms. Bird: (interrupts) Right, really understood it...they really understand how energy is transferred in the food web. [much later in the discussion]... I love this answer, it said three times as many humans would be able to feed from the second trophic level instead of the fifth. So that shows that they understood. It doesn't explain why, but they used vocabulary. So I love that.	We are looking at student-created food webs in a small group. Ms. Bird states her criteria for conceptual understanding of food webs. Later in the discussion, she accepts use of vocabulary as evidence for understanding, abandoning her previously stated rubric, revealing she is *listening for* correct student responses.

In this discussion, we had asked the teachers to sort the student work into high, medium and low examples. Several teachers had read identical answers, which they accepted as high. My repeatedly pushing them to consider what these answers show about student thinking is largely ignored until Ms. Hill finds the same passage it the textbook. Even then, it is not clear whether the teachers still accept the students' demonstrated ability to find the relevant passage in the book as proof of their understanding.

Ms. Anderson: So how did your kids answer the one about 'Where does the energy go?' If it's not used... ***Ms. Hill: [reads from student paper] It either transforms into heat or it remains in the portion of food not eaten or not digested.*** *Ms. Anderson: [Can't hear, question.]* *Mr. Carter: That's almost word for word from the book, I think.* *Vickie: That sounds like what the book says.* ***Ms. Hill: [reading from another paper] 'It goes to the plants and the trees.'*** *Ms. Anderson: My kids said... 'This energy is burned as the prey uses it to try to escape from the predator.'* *Mr. Carter: I have that, I got that.* ***Ms. Hill: [can't hear.]*** *Mr. Carter: It goes away, it goes to the consumer, it's wasted.* *Vickie: What does the book say?* *Mr. Carter: The book says it's lost as heat.* *...[Ms. Bird explains what she told her students. She expresses disappointment at not finding it in their answers.]* *Vickie: A lot of it sounded right, just word for word from the book.* ***Ms. Hill: That's what this person said. [Opens a textbook, thumbs through pages.]*** *Vickie: Okay. So they're good at copying out of the book, but we don't know if–* ***Ms. Hill: [interrupts] [reading] 'Some is transferred to heat and some remains in portions of the prey not eaten or not digested.' It says, 'A large portion is lost as heat and cannot be used by the consumer. It's lost to the environment. It doesn't disappear, but it takes forms that are not usable by the consumer.' So it doesn't really tell them what happens to it.***	The camera is not turned on this group when this small group discussion begins. According to field notes, Ms. Hill reads two identical student answers which she rates as high. The facilitator grows suspicious and suggests that these do not reflect the students' own thinking. Mr. Carter is the only one of the five teachers in the group who attended to the issue the facilitator raises; the others seem to ignore it until she has pushed them 3 more times. Finally Ms. Hill actually looks at the text and discovers the answers she considered high were copied directly from the book. After reading, Ms. Hill decides that the book really does not give a direct answer to the question, thereby seeming to miss the point that students' use of vocabulary is not by itself an indicator of conceptual understanding. The 5 teachers are not interested in pursuing this line of inquiry, and facilitator decides to let the matter rest. We believe it is further evidence of the teachers *listening for* rather than *listening to.*

Three months later, in February, Samantha's thinking about the obstacles to inquiry has become much more focused. In February, Samantha, Ms. Bird and another teacher took 70 students to a local park for a "Science in the Park" day. These high school students organized

and led 400 local elementary school children in a day of science activities focused on environmental education. Samantha considers this kind of out-of-classroom experience to be the most effective part of her practice. In addition to Science in the Park, the two teachers collaborate on several field trips: This year they have had or plan trips to Malibu Creek, Death Valley, Joshua Tree National Monument, Big Sur and the Grand Tetons. We had been curious as to why both Samantha and Ms. Bird do not incorporate more of the open-ended inquiry they describe on their trips into their regular classroom practice.

Vickie: Do you think this changes what you do in your classroom? *Samantha: Yeah. [pause] The only problem is the kids are not all in one class.* *Vickie: Yeah.* *Samantha: But then [it affects] the classes that they're mixed in.* *Vickie: You couldn't do this in a regular class?* *Samantha: Well we do. It changes what you do, because it changes kids' perceptions about themselves...So I think that changes everything.* *Vickie: Uh huh. I was just wondering [pause] I mean for myself, I was moving towards less and less structured activities and more and more//* *Samantha://It's hard to figure out assessments that show the progress the kids have made. It's hard to show where they started out and where they are and some points along the way. It's like that anyway, even when you are structured, it just seems like it's more//* *Vickie: So//* *Samantha: I feel like I need to do more backward planning, so I need to have a clear idea what my expectation is before I start so when I let them go, but less structured. Because if I don't, it's harder for me to tell what we've accomplished. I know I have, when the kids say things like, 'Thermodynamically, your room sucks.' But I don't have that in an assessable manner.* *Vickie: Are you under constraints to do that?* *Samantha: Well like with the Boards, yeah. Like I thought that thermodynamics unit was a good thing and I wanted to use that for my teaching a major idea over time. But I have to show clear and concise evidence that the two students I choose progress. And I only have three assignments to show that. And I know they learned thermodynamics, they have a much better understanding of heat and energy, but I don't know that I can show that in 3 papers.*	Before I have the presence of mind to turn on the video camera to record this impromptu interview, Samantha tells me how she has selected some of her worst students, "the ones you're afraid to leave with the sub," to come on the trip. She reports these students almost always are conscientious and responsible, "the best ones." This has captured my attention. I wonder whether Samantha has considered incorporating more of this type of activity into her routine practice. It appears Samantha understands my questions differently than I meant them. She believes the field trip experiences change students' attitudes toward traditional practice rather than her approach to teaching. Pushed a little further, Samantha identifies the need for assessment as the limiting factor in using inquiry. She seems to know that if her practice were more open-ended, she would have to think differently about teaching. She identifies the National Board Certification process in which she is currently engaged as constraining her from using inquiry as she understands it. We suspect difficulty also lies at a deeper level, in issues of teacher identity – Samantha's perception of what it means to be a teacher.

Based on what we have learned from analyzing teachers' talk at the BFFS project, we would predict exactly the kind of issues in understanding and evaluating students' thinking which Samantha expresses. The requirement of the National Board, that teachers demonstrate students' conceptual growth in the work they submit, creates a direct challenge to her identity as a science teacher. In a school site meeting (January, 2002) she expresses frustration that her idea of best teaching practice is not acceptable to the Board. *"I'm doing hands-on, for heaven's sakes! What do they want?"* Most recently, March 25, 2002, while attending a follow-up to the National Academy for Curriculum Leadership Academy, Samantha pondered out loud, *"I'm beginning to question whether I'm teaching inquiry at all."*

Identity, Professional Development and Science Teaching We believe Samantha's trajectory can be understood using Cain's model of identity dissolution-acquisition. She started in our professional development with a strong identity as being in the vanguard of progressive science teachers, using hands-on activities to motivate and enhance student learning. Like most of the teachers in our group, she conflated inquiry and activity-based instruction, being basically oblivious to the issues of discourse and epistemological assumptions distilled in our distinction between *listening to* and *listening for*.

We infer that six months of professional development and intensive one-on-one mentoring have helped bring Samantha to the point of identity dissolution. Her simultaneous participation in the National Board Certification process as well as the National Academy for Curriculum Leadership bring further pressure for her to examine her ideas about what makes a good science teacher.

The persistence of teachers' knowledge and beliefs about practice in the face of policy

mandates and reform movements is well established. Often seen as puzzling and irrational, it becomes more comprehensible when practice and identity are seen to be mutually reinforcing, a sort of feedback loop. Our model predicts another paradox: Teachers such as those participating in our professional development – teachers whose dedication and commitment to their students far outpaces the norm for the profession, experienced teachers who have many years invested – may actually have a harder time letting go of old identifications with practice in order to accept new ones than those whose identities as teachers are less formed. This correlates with the persistent finding that veteran teachers resist change, but provides a more positive assessment of its roots. In truth, it seems to us that Samantha and her colleagues exhibit extraordinary courage in trying to make sometimes (and obviously) painful changes in their identities as science teachers.

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