

# Professional development in person: identity and the construction of teaching within a high school science department

Victoria Deneroff

Received: 19 September 2013 / Accepted: 19 September 2013 / Published online: 30 November 2013  
© Springer Science+Business Media Dordrecht 2013

**Abstract** This is a narrative inquiry into the role of professional development in the construction of teaching practice by an exemplary urban high school science teacher. I collected data during 3 years of ethnographic participant observation in Marie Gonzalez’s classroom. Marie told stories about her experiences in ten years of professional development focused on inquiry science teaching. I use a social practice theory lens to analyze my own stories as well as Marie’s. I make the case that science teaching is best understood as mediated by socially-constructed identities rather than as the end-product of knowledge and beliefs. The cognitive paradigm for understanding teachers’ professional learning fails to consistently produce transformations of teaching practice. In order to design professional development with science teachers that is generative of new knowledge, and is self-sustaining, we must understand how to build knowledge of how to problematize identities and consciously use social practice theory.

**Keywords** Professional development · High school science teaching · Inquiry science teaching ethnography

How can we design professional development for science teachers in ways which foster high school science teaching for social justice and equity, classrooms in which all students, regardless of race and social class, experience meaningful science learning? I now have had some eight years of experience as a high school science teacher, eight as a graduate student in an urban schooling program, and ten as a teacher educator and researcher. In my professional roles I have observed more than 100 secondary science classrooms in which teachers lectured to students who copied “notes” verbatim off the board; they assigned worksheets, vocabulary lists, and the questions at the end of the chapter. They held class

---

Lead Editor: J. Adams

---

V. Deneroff (✉)

Department of Advanced Teacher Education, John H. Lounsbury College of Education,  
Georgia College & State University, Milledgeville, GA 31061, USA  
e-mail: victoria.deneroff@gcsu.edu

discussions in which one student's answer was taken as proof of general understanding. Making "foldables" and concept maps seems to be an activity increasingly popular with teachers and students alike; concept maps are a research-proven strategy, except that in all instances I have witnessed, teachers told their students what to put in the bubbles or folds. This circumvents the intent of mapping as a tool for thinking, and is representative of what I have seen happen consistently: research-based, constructivist strategies are instantiated in behaviorist ways. Students also often made posters or PowerPoints for presentation to an audience of their peers, who generally did not listen, and spent a great deal of instructional time making their presentations look pretty. They copied the standard off the board, and the teacher conducted a recitation lesson on the language of the standards, rather than actually teaching science. Rare laboratory activities provided step by step instructions that do not require thinking. In fact thinking has been notably absent overall, and the overwhelming majority of students, when I have questioned them out of curiosity and my own boredom with the lessons I am witnessing, have told me science is boring and they hate it.

This is an old story, told 25 years ago by Kenneth Tobin and James Gallagher (1987), really going back at least 100 years to John Dewey (1916). Some of these hundred plus teachers, who seemed to be very nice people, explained to me how important hands-on science is for students' learning, leading me to smile politely and stifle my real opinions. All had been through teacher education programs of one kind or another, some high-quality, others not, and at minimum all had participated in professional development and content-specific learning provided by their schools and districts. Clearly they either missed the point of the science teacher education they had received, or were not able to sustain it within the culture of schools. What is troubling is they thought they were using constructivist strategies.

Barbara Crawford (2007) concluded in her case study that five novice teachers found it almost impossible to use inquiry when they encountered school culture, what she called "the rough and tumble of practice" (p. 613). Crawford identified one of the correlating factors as how novices' knowledge and beliefs about inquiry teaching did or did not mesh what they had learned in education school. In this essay article, as I develop a narrative inquiry into the role professional development played for an in-service science teacher, I am going to propose an alternative explanation: *it is not the knowledge and beliefs held by science teachers which mediate their practice, but rather the on-the-job social construction of what it means to be a science teacher*, what I am calling identity.

In only thirteen classrooms, including my own, have I witnessed teachers attempting a connected picture of the concepts of science, or requiring students to explore the nature of science as a culturally-devised way of knowing, or even asking students to think. I might add that two instances were student teachers using reform strategies their mentor teachers openly disparaged as worthless. I remember these reform-oriented classrooms well because I felt joy just being in the room, seeing students really dig into important ideas and feel pride in being science learners. These outlier classrooms, then, make me wonder why about ten percent of the science teachers I come into contact with actually teach in ways that are consistent with what we know about how students learn science. Could it be that only about ten percent of the people who become science teachers are talented enough to do so? I argue this is not so.

In his book, *Outliers: The Story of Success* (2008), Malcolm Gladwell makes the case that successful people in any field always have social networks that support them and make their achievement possible. He argues that star hockey players, the Beatles, Bill Gates, and others, had to be "good enough," but not necessarily prodigies. As much as talent, genius requires both opportunity and prodigious amounts of practice, which Gladwell quantifies at 10,000 h based on a number of studies of expertise. How can science teachers' professional

learning opportunities be structured in ways that made excellent science teaching the norm, and poor teaching the outlier?

I offer this narrative inquiry into the connection between teaching practice and experiences in professional development as a way of thinking about conditions necessary for teachers' generative learning. I propose that professional development as aimed at promoting high school inquiry science teaching occurs "in person," mediated by the body, mind and subjective histories of persons engaged in science teaching. I work within the strand of social practice theory (SPT), developed by Jean Lave, in which learning is defined as, "transformation of identity" (1996). Identity in the literature of SPT, means individuals' understandings of (1) who they think they are within a particular community of practice, and how they understand themselves as becoming that person (Wenger 1998); (2) who people think they are as constructed through interactions with others who tell them who they are (Holland et al. 2001); and, (3) who they are in relation to others' identities within a fluid, shifting nexus of place, time and social interactions. My goal is to develop and use these theoretical constructs to show how an SPT perspective provides a rich and powerful theory of teachers' learning in practice. Using themes developed from participant observation of/with Marie Gonzalez, an inquiry-using high school teacher, her narratives about professional learning and her work life, I will tell a story of how identity mediated the way Marie transformed ideas from professional development into the daily practice of inquiry teaching.

### Ethnographic methodologies

I cannot tell Marie's story without telling parts my own, as the intersection of our intersecting, impassioned commitments to science education for all students is the ground from which this ethnography arose. H. Lloyd Goodall (2006) explained his own "ethnographic turn" toward interpretive studies, in which writing is itself the data analysis. I do this with some reservations: how am I going to be "objective?" Graduate school methodology courses and scientific training have made me suspicious of subjective accounts. Moreover, how do I decide what to include and what to leave out? There is much, much more data than I can possibly analyze in a short paper. I see it as a tangled gestalt, and my instinct is to include as much information as possible so the reader can understand my interpretations. However, space and patience are limited, so I have followed Goodall's rule, "...[I]n the interest of telling a good story it is permissible to omit details that have no bearing on the tale, but it is *not* permissible to make things up" (Kindle edition, Location 1518 of 2633).

### Writing as a research method

I structured this paper to communicate a multidimensional, broad and yet particularized representation of one inquiry teacher's practice and its implications for professional development. In my own scholarly practice, I have found "I don't know what I think until I write," and therefore consider writing to be an essential part of methodology. The finished paper is thus a tidied-up record of ideas worked through, a methodological point which Julie Colyar (2009) makes.

### *My history as a science teacher*

I was a high school science teacher in what I will call The District, a very large (geographically and in terms of number of students) educational institution on the west coast,

starting in the 1980s, with time off for family and an art career. I was quickly disillusioned by the bureaucratic, uncompassionate treatment of the vast majority of students relegated to lower and middle tracks. In my school, there were five levels of biology: remedial, regular, academically enriched, honors, and advanced placement (AP). Based on my participation in the science department, only the honors and AP students were of interest to teachers; the others received low-level instruction in vocabulary, many worksheets, a very few cookbook labs and little opportunity to learn conceptually. Andrew Gilbert and Randy Yerrick (2001) wrote about similar circumstances in a rural North Carolina high school, where a teacher's low opinions of low track students resulted in students' disengagement.

I threw my soul into teaching as creatively as I could, and did art on the weekends. In the mid-1990s, one of a series of superintendents decreed that all high school courses would henceforth be "college prep," eliminating remedial classes. This top-down mandate came with no funding, and no preparation of teachers or school-site administrators, a pattern which is consistent with Charles Payne's experiences in the Chicago Public Schools and he argued, more generally throughout urban education (2007). In the meantime, I had affiliated myself with The District's Urban Systemic Initiative (USI), and received grants for teaching integrated science, a new college preparatory course, along with 3 years of professional development in pedagogy and teacher leadership. At the time, integrated science was "in the air;" before joining the USI I had actually tried integrated lessons that crossed boundaries between physical and life science, and also included art and creative writing. Since The District had eliminated remedial science, it took little persuasion to get the head counselor to open up ten sections of Integrated Science 1 (IS-1), although he did not quite understand that IS-1 was not a remedial course.

### *Becoming a facilitator of professional development*

During this time, as coordinator of IS at our school, I facilitated curriculum development meetings with the science department. I was puzzled and angered by the refusal of all but one colleague out of 14 to budge from a commitment to traditional science teaching. The D-F rate in science was 40 % across all classes, and considering that most in the high-track magnet classes got high marks, the percentages in low-track classes were much higher. My fellow science teachers continued to grouse about the students who couldn't think; they used instructional time showing videos almost no students watched, and assigned lists of facts to memorize for tests, mostly failed. They refused to believe that anyone but the gifted would benefit from doing inquiry, in spite of evidence to the contrary emanating from my classroom. As they passed by the open door or walked into the stockroom, on most days they saw 35 busy, engaged, brown-skinned young people, some designated limited English proficient, noisily looking through microscopes, titrating, observing, sketching, discussing conclusions, and even doing DNA electrophoresis with equipment and chemicals borrowed from biotechnology company Amgen. I was astonished that the other science teachers seemed to feel threatened by the success of students in my classes. Were they not exceeding my or anyone else's expectations for them, something to be celebrated? Had I not transformed my teaching through participation in professional development? Why did my colleagues repeatedly tell me that professional development was a waste of time?

One day one of the pioneers of our school, an algebra teacher who had been on the faculty since it opened in 1968, accosted me in the hall.

“I hear you gave Sean an A.”

“Yes, he earned it.”

His response was something like, “We just don’t have the quality of students we used to have.”

I asked, “Why is that?”

“Just look at what color they are,” he replied.

I’m guessing that, although most of the faculty was not as blatantly racist as this man, many held similar opinions, that is, they constructed my students’ success as not genuine because I must be “dumbing down” my curriculum. In actuality, the cognitive demands of my classes far exceeded what was happening in the other low-track classes. However, the social practice of holding students of color to high expectations and giving them enriched opportunity to learn, was not shared by my colleagues.

The leaders of the USI asked me to lead professional development workshops and to speak at meetings. I was acutely aware that I had, and continue to have, shortcomings as a teacher. My attitude was, “If I did it, you can do it too.” The audiences however, seemed to have a different take: After one such presentation, I spoke to encourage a teacher from another high school to experiment with inquiry, that students would learn more. “You’re just a good teacher,” she said, and walked away, leaving me speechless. I already had the suspicion the defensive bad-mouthing of students and the despair, which permeated the talk of my colleagues, masked feelings of profound inadequacy. Charles Payne (2007) calls such teachers demoralized. Although I continued to be angry at the damage being done to students by schooling, I increasingly understood that teachers were just as hurt. These recalcitrant colleagues—people I generally liked and called friends—were doing the best they could, most of them working very hard with very little emotional reward. How could professional development for science teachers actually bring about transformation of schooling? To find out, I applied to a PhD program in urban schooling, was accepted, and resigned my teaching position.

### *Becoming an educational researcher*

Late in the spring term of that first year of graduate school, the learning theories and investigations into the culture of schooling which were my course of study led to an jolt of insight, which I remember clearly enough to recall where I was when it happened. *All students don’t learn because nobody expects them to.* Ideas from a number of theorists came together in my head, including Pierre Bourdieu’s argument that the school evaluates knowledge it does not teach (Bourdieu and Passeron 1977); and Karin Martin’s (1998) evidence that preschool teachers (and others) construct gender in very young children so that it comes to be seen as natural. The keystone of the arch under which I passed was Elizabeth Cohen and Rachel Lotan’s (1997) work showing the profound positive effects of changing teachers’ expectations of low-achieving students. I realized the problem with schooling was extremely simple, and at the same time extremely difficult to fix. Clearly I had to better understand culture and the role of school culture in teaching practice if I was going to better understand how to design professional development. As I was involved as a graduate student researcher in a couple of professional development projects, I made plans to study the interaction of professional development and school culture. I contacted teachers from the project who seemed to be making changes toward inquiry science teaching, and they agreed to be part of a study.

### *Beyond Final Form Science (BFFS)*

The research described in this article had its beginnings in a larger professional development effort in which I was a graduate student researcher, BFFS, conducted over 3 years. The name reflected our desire to move teachers beyond an epistemology that considers science to be a body of known facts (Duschl 1990), and toward an inquiry-oriented classroom practice.

#### The bounds of the ethnographic study

I began the research that resulted in this case study of Marie Gonzalez's inquiry teaching during the first year of BFFS, when I visited her classroom as part of the project. I came twice, video recording her teaching and taking field notes of our conversations. I asked Marie to choose a pseudonym for the research, and she instantly replied, "Marie," explaining that it was her mother's name. Gonzalez I chose to preserve her Latino background. (All other names and places described in the article are also invented.) Although I observed and recorded other teachers, Marie consistently showed that she had internalized professional development in ways that seemed to be self-sustaining and generative (Franke et al., 1998), continuing to resonate through her practice once her participation had ended. It seemed that observing and analyzing her teaching would provide an opportunity to see how professional development entered practice.

Marie was one of six teacher-leaders who emerged from BFFS. This group referred to themselves as "inquiry teachers," and adopted the name "The Team". However our own observations of their teaching led us to conclude that of The Team, only Marie and Grace actually engaged in exemplary inquiry practice. Based on text analysis of audio recorded conversations between Marie and Grace, I developed the following criteria for inquiry science teachers: *inquirers* who develop students' questions; *guides* to helping students find answers through active learning; *designers* of laboratory experiences resembling authentic scientific processes; *knowers* of the canon of science concepts and the nature of science; *assessors* of students' development as science learners; and effective *classroom managers* able to teach in the time allotted by district curricular requirements and standardized testing (Deneroff 2012). Note that I refer to *identities* of science teachers, that is, what teachers and others understand themselves to be, rather than actions such teachers take. The definition, derived from the talk of expert inquiry teachers, is similar to that proposed by Tali Tal, Joseph Krajcik and Phyllis Blumenfeld (2006).

Once BFFS was complete, The Team began working with other teachers of integrated science at their schools to design curriculum and conduct investigations into students' thinking. Connecting with the University Science Project, ultimately The Team became the only providers of science teacher professional development for all 49 high schools in The District.

The BFFS experience was frustrating, in that we had clear evidence that only 3 of the 30 teachers (10 % again) had understood the inquiry paradigm and been able to use it with their students. 90 % grafted the ideas of inquiry onto traditional methods, continuing to tell students the facts of science, or perhaps even more discouraging, turning students loose with materials without clear objectives or connection to ideas of science, resulting in little learning, chaos, and boredom.

### *Representing Marie while maintaining integrity*

“Because language is symbolic, and reality is not, these two domains [language and reality] are obviously not alike...” (Goodall 2006, Kindle edition, location 93 of 2633). In attempting to find meaning and insight by writing about teachers’ experiences with professional development, I find myself facing the well-documented crisis of representation, that is, how can any written account, whether modern or post-modern, pretend to interpret lived experience? I have come to respect Sandra Harding’s compromise, what she called “strong” (1998, p. 18), rather than absolute objectivity, as the best I can do.

In the spirit of strong objectivity, I have made my personal stance and position during the research as explicit as possible, by telling a bit of my own story. As Laurel Richardson (2008) wrote, “Knowing the self and knowing about the subject are intertwined, partial, historical, local knowledges” (p. 929). I approach the telling of another’s story with some trepidation, realizing I have no particular right to represent another’s experience. Therefore I have included a little of my own narrative as a way of introducing the reader to the experiences which motivate me to pursue this line of inquiry.

I understand the writing of ethnography as an almost solemn responsibility, and then must laugh at myself for delusions of grandeur. At the core, I write because I am distressed by the state of science education in the United States, and convinced that improvement requires understanding the social construction of teachers’ identities. I will examine the experiences of an outlier teacher, one of the 10 %, in order to understand how professional development became part of her work in the classroom.

### *Participant observation*

The ethnography that emerged as my research underscores its “inductive, interactive and recursive” nature (LeCompte and Schensul 1999, p. 15). As part of BFFS I visited Bahia High School on a monthly basis, sometimes more; in the second year of BFFS I spent 9 days over 3 weeks shadowing her; during that time Marie wore a remote microphone and I audio-recorded all of her speech. I transcribed the audiotapes and coded them. In addition, I took field notes of all my observations. I videotaped an additional 4 h of classroom instruction, which also were transcribed. I spent many hours after school talking with her. I visited Marie on the first day of school in year three, audio recording her for the entire day. During this year I also attended two professional development meetings for IS-1 teachers, which Marie facilitated, as well as a meeting of The Team.

Throughout I interviewed Marie for many hours, asking her to explain her viewpoint on what I had observed; most of these interviews were also taped and transcribed. The BFFS professional development meetings were videotaped by the university project, and I had access to the tapes and their transcriptions. I also traveled to four conferences with Marie, during which I sometimes took field notes. Finally, Marie read drafts of the original ethnography (Deneroff 2004) and made comments, clarifications and corrections, which I in turn incorporated into the text. As a participant observer, I was able to situate her narratives with observed teaching and non-teaching interactions with students, colleagues, and school administrators, university personnel, as well as my own experience of attending professional development first as Marie’s colleague and later as a professional development facilitator.



## Marie Gonzalez's teaching and professional development history

### Teaching at Bahia High School

The study took place in a large urban district in California. Bahia High School, where Marie taught, Bahia High was diverse, with various Latino ethnicities, Filipinos and African-Americans in approximately equal numbers; there were also about ten percent Caucasian students and others who had come from many different parts of the world, including a significant contingent of students of Polynesian ancestry. Most of the students were poor and the school received Title I funding. Marie was herself a graduate of Bahia High School, and spoke of her high school years often. At the time the study began Marie had been teaching for nine years, was the science department chair, a member of the school governance council, the science department literacy coordinator, and sponsor of three clubs for students.

Marie taught two sections of Integrated Science 1 (IS-1) to ninth graders, one of Advanced Placement Environmental Science, and one Chemistry within the Multicultural Language Academy (MLA). The MLA was a specialized school-within-a-school program, which attracted college-bound students, ostensibly those who planned to become teachers after graduation from college. MLA students came from Bahia's three feeder middle schools, and it was not considered a "magnet" program. The MLA attracted "good but not gifted" students on the basis of a reputation for superior instruction; Marie reported very few of them actually intended to become teachers.

I observed Marie to spend almost as much time with students outside of class as she did in formal teaching; at the same time her teaching was often informal. During the second year of data collection, Marie was advising the Environmental Club about planning and raising money for a summer trip to Hawaii. In early May, once AP testing was complete and AP classes were "finished," Club members, many of whom were juniors and seniors in AP classes, were found in her room even while she was teaching other classes; during times when students were working independently they would consult with her about club activities or questions about school and life.

Considering age of the IS-1 students (14–15), the crowded conditions, and the freedom that Marie allowed them, the classroom was remarkably quiet. I only heard her raise her voice in frustration once. Observing on the first day of school I saw her use no particular strategies to keep students quiet; I infer students' engagement developed over time as she established relationships with them. Her classroom space was large, but the perimeter was taken up by lab benches, some of them piled high with boxes. The tables for 36 students were clustered in the center and made the room feel very small. Marie's desk, where she occasionally sat, was toward the center of the room, placed among students' tables and level with them. Visiting students and student lab assistants often occupied a couch located behind the desk, and they freely entered and exited through the stockroom door. One day she interrupted class to organize carpools to the regional softball finals where Bahia was playing. When I asked her about this event, she told me that she herself had played softball, and she thought it was really important for her students to develop "school spirit."

Both inside and outside of class she asked students questions about their personal lives and seemed to know a great deal about them. She was also open about her own history of childhood problems and the importance of her relationships with her large extended family that lived nearby in the community. Her two nephews graduated with honors from Bahia; one was now a minor league baseball player and the other was attending the University of



Pennsylvania. During the first year of the research, her nephews dropped by twice to visit with Marie and students. She told me they were good role models for students.

Being a role model herself occupied a great deal of Marie's time and energy—I would venture to say as much as went into the activities that would normally be called *teaching*, such as providing instruction, planning lessons, and grading assignments. As an observer, it was not always easy to draw a distinction between her performances as instructor and mentor. Her identification with Bahia had been a major factor in her own successful navigation of a tumultuous adolescence, and she expressed the desire to support students as she had been supported.

Marie did not hear about the importance of being a role model for students in the ten professional development (PD) projects focused on inquiry teaching she attended over nine years. Since I was present at all of these but one, either as an observer, provider or a consumer, I know that these projects did not talk about relationships with students except in abstractions such as “engagement” or “motivation.” For example, in BFFS we discussed curricular rationales from learning theory and how-to's of inquiry activities. We asked teachers to understand the thinking behind students' answers, and to consider the social and epistemic ramifications of what we know about the history of science. We designed these activities using a cognitive model of learning, stressing learners' construction of knowledge. We understood that learning occurs through social interaction, and asked our participants to work in small groups and produce posters and other artifacts. However we maintained what Jean Lave (1996) calls an individualistic and psychological set of assumptions, that is, operationally defining learning as a change in what an individual knows, believes and can do. Such a framework assumes that experts provide novices with experiences that enable them to become more competent individuals, without attending to participation of students or teachers within communities of practice. I have since come to understand that a perspective on learning as transformation of participation occurring reflexively in communities and individuals, such as proposed by Barbara Rogoff (1994), provides a more reliable lens for understanding the trajectories teachers take in becoming inquiry science teachers.

Because it centered on cognition, the PD Marie attended missed probably half the important social practices that constituted her teaching. In interviews and conversations with Marie about her relationships with colleagues, as well as observations of the interactions she had with other teachers in her school, cognitive aspects of teaching rarely came up. I wonder whether social practices and identities that excluded cognition from conversations about teaching was a root cause of the phenomenon I observed during my own high school teaching days: were colleagues telling me professional development is a waste of time. The teachers were focused on the reality of their daily, complex interactions with living human beings, while PD dealt with abstract students.

### **Developing a theoretical framework for understanding teachers' learning**

My adviser in graduate school, Megan Franke, researches professional development for elementary school mathematics teachers. She is convinced that the cognitive paradigm for teacher professional learning does not adequately support teachers' generative change sustainably over extended periods. In our conversations, she pointed me to a study she conducted with Elizabeth Fennema which demonstrated no correlation between teachers' stated knowledge and beliefs and their classroom practice (Fennema and Franke 1992). She argued sociocultural theories of learning, particularly the ways in which identity mediates

practice, were far more likely to predict outcomes of professional development. Her own design of professional development as well as her research, in which I participated, was aimed at teasing out the role of teachers' identities in professional learning. She argued that sociocultural constructs of identity had more relevance to the understanding of teachers' generative change, that is, professional learning that continued once the PD was completed.

### Professional development and identity in the cognitive paradigm

Marie described attending ten important professional development initiatives over her career. (see Table 1). She said there were a number of others, including those sponsored by The District, but felt that they had not been useful for her teaching. These professional learning opportunities introduced participants to ideas about inquiry science teaching. While those involved in providing programs for teachers' learning, including myself, undoubtedly experienced them as embodied, situated and storied, for Marie they were outside the practices of teaching in her classroom, and thus ahistorical in terms of her day-to-day practice with living human beings. By the time of our ethnographic work together, she endorsed herself and was endorsed by others as "an inquiry teacher". I propose that professional development became situated, embodied and storied through transformation of identity, her understandings of herself as an inquiry teacher.

The theoretical and intellectual framework of inquiry teaching has cognitive, epistemic and social dimensions (Deneroff 2012). Marie's ideas about inquiry had their origins in professional development and studies in a master's program in science education, as well as her experiences at Bahia High School. There was a direct relationship between theories of inquiry and the professional development that introduced Marie to these ideas. Still, their incorporation into her repertoire of teaching practices occurred through the mediation of identity—her practice of being the kind of teacher she was, and her knowledge of how that teacher came to be—practice and identity reflexively defined her teaching self.

Understanding the relationship between professional development and teaching practice thus requires abandoning traditional views of learning in order to get at its essence. The dominant cognitive paradigm for understanding science teaching is positivist and linear. By this I mean its adherents generally seek knowledge of how to reproduce, scale up, and transfer models for science teacher professional development (Borko 2004), by identifying what kinds of programs will foster teachers' knowledge of what they need to know about inquiry teaching. Such studies are based on sequential and deterministic input–output models in which "human nature is fixed and largely contingent on brain mechanisms" (Stetsenko 2008, p. 473). The tradition of cognitive, dualistic studies includes "social learning" described by most constructivists (i.e. Fishman, Marx, Best, and Tal 2003), in which learning is seen as unidirectional, from environment to individual.

Individual psychological (cognitive) models of identity posit a relationship between teachers' knowledge and beliefs and the way they teach. There are multitudes of studies in this strand of research; many of these were reviewed by Jan Van Driel, Nico Verloop and Wobbe de Vos (1998), who argued that changing teachers' knowledge and beliefs is the essence of moving them toward reform science teaching. Other studies of teachers' identity use no explicit theoretical framework: in their review article, Douwe Beijaard, Paulien Meijer, and Nico Verloop (2004) endorsed a linear conception of identity: "Our concept of self can be defined as an organized representation of our theories, attitudes, and beliefs about ourselves" (p. 108). Within the cognitive paradigm, these theories of self, attitudes and beliefs have been assembled from internalized effects of social interactions and experiences in society, and provide a way to look at individual knowledge and beliefs.

**Table 1** A chronology of events described in this study

Year	Events
1993	Marie began teaching
1994	Recruited by Jack, started at Playa Attended teacher certification program at State University
1996	Became lead teacher for USI Attended SEPUP training for <i>Issues, Evidence and You</i> Attended teacher certification program at State University
1997	Lead teacher for USI Participated in SEPUP Assessment System field test Field tested <i>Science &amp; Sustainability</i> for SEPUP
1998	Lead teacher for USI Piloted <i>Science &amp; Sustainability</i> for SEPUP Was trained in <i>Active Physics</i> curriculum by It's About Time (purchased by USI) Masters program at State University
1999	Lead teacher for USI Facilitated <i>Science &amp; Sustainability</i> assessment for SEPUP Masters program at State University
2000	Field tested <i>Active Chemistry</i> for It's About Time Masters program at State University
2002	Became department chair Joined University research project Masters program at State University
2003	Went to NACL Became a <i>Science &amp; Sustainability Trainer</i> Masters program at State University
2004	Went to NACL Attended <i>Earth-Comm</i> training (It's About Time) Attended University research project Attended District Institute for Learning p.d. Masters program at State University
2005	Went to NACL Became science literacy coach at Playa HS Attended West-Ed Reading Apprenticeship Training Oil company professional development Attended District Institute for Learning p.d. Became member of "The Team" Facilitated p.d. for District. Obtained Masters degree
2006	Member of "The Team." Left teaching.

Marie's participation in professional development discussed in the article is included. Note that there were other "trainings" (her words) she attended that she did not mention as being key to her understanding of classroom practice

## Big-I identities and social practice theories

Extending sociolinguist James Gee's (1996) construct of Big-D Discourse, I will use the term Big-I Identity, Inquiry Science Teacher, to indicate those who construct an Identity as a certain kind of person, an identity which mediates learning and participation in social practices. I have earlier characterized inquiry science teaching as marked by a Discourse of Inquiry Science Teaching using Gee's model (Deneroff 2004). Gee describes how discourse communities create self-delimiting spaces which mediate meaning, "resistant to internal criticism and self-scrutiny, since uttering viewpoints that seriously undermine them defines one as being outside them" (p. 132). This means that ideas that are not within the Discourse are either rejected ("I hear Sean got an A.") or transformed to fit it (teachers telling students what to put in concept maps).

Andreas Reckwitz's definitions are useful in thinking about SPT, "[S]ocial practices are sets of routinized bodily performances... [and] are at the same time sets of mental activities" (2002, p. 250). Practices are social actions and talk, which are recognizable as purposeful to other members of the community. During my entire time with Marie, I never, not once, heard her complain about a student or group of students. When I asked her why she avoided the teachers' lunchroom, she told me the people who went there for lunch were "negative." Using SPT, I understand that the social practices of the lunchroom crowd were not consistent with Marie's Identity as an Inquiry Teacher, nor was her speaking of students in only positive ways consistent with their ideas about how to be a teacher at Bahia High School. In this way, identities are practiced, that is, they exist as social practices others understand. Anna Sfard and Anna Prusak define identity as a collection of "reifying, significant, endorsable stories about a person" (2005, p. 11). Using this definition, members of The Team endorsed each other as inquiry teachers, although outside observers might not, and developed a strong identity as being that sort of teacher. When I asked Marie:

Victoria: So how committed are you to inquiry?

Marie: Just inquiry in general?

Vic: Yeah

Marie: Just being an inquiry teacher?

Vic: Yeah

Marie: Pretty committed, I think

Vic: If the State told you tomorrow that you can't use inquiry, what would you do?

Marie: I can do whatever I want to do. I mean, if they told me I had to do direct instruction, I would find a way to make it so that my kids were doing inquiry with what the State wanted me to do. That's how I would do it. So, there's no way that I could stand up and lecture to my students. I mean, just solely without them doing any investigation whatsoever on their own. I mean, I guess that could happen, I guess anything's possible

Identities exist as social practices, they are reified within a particular community by persons who recognize them as meaningful because of the things they say and do. Holland, Lachicotte, Skinner and Cain (2001) conceptualize practiced identity as allowing the individual to act within socially constructed worlds, and providing a "space of authoring" (pp. 273–274). Their metaphor, derived from Mikhail Bakhtin (1986) provides a way to locate identities in specific times and places; rather than thinking of them as a plate of options the individual may choose from, it points to the reflexive way identity creates and is created by persons in social, historical situations.

## SPT and cognitive paradigms are incommensurable

The cognitive perspective does not provide a satisfactory explanation for a persistent research finding: most science teachers continue to teach in traditional, transmission-of-information ways, even after participating in professional development designed to move them toward more reform-based practice (Windschitl 2004). Writing about the results of a study that showed little effect of extended professional development on the mathematical content knowledge of 1,000 middle school mathematics teachers, Heather Hill (2011) wondered whether professional development aimed at increasing the content knowledge of mathematics teachers *might* be a waste of time and billions of dollars, although further research is necessary to reach this rather astonishing conclusion (p. 226).

Using Thomas Kuhn's (1996) model of paradigm change, I argue SPT and cognitive paradigms are methodologically incommensurable, because they understand what counts as data in mutually exclusive ways. In addition, there is a semantic gulf, in that the assumptions of each are incompatible (p. 175). The central concepts of SPT, reflexivity and mediation, have little meaning in cognitive theories of learning. The underlying assumption of SPT is that social practices are words and actions that others recognize as meaningful and which structure the social world for individuals. The foundational assumption of knowledge-and-beliefs research is that an individual's actions are caused by what s/he knows and believes. In the cognitive paradigm, discrepancies between knowledge, expressed beliefs and actions are considered to stem from the researcher's failure to correctly identify knowledge and beliefs (Hashweh 2005).

Social practice theory does not require that practices are consistent with each other or with an individual's knowledge and beliefs. Thus, SPT eliminates one of the fundamental difficulties with research into teachers' cognition: the persistent gap between what teachers tell us they know and believe and what they are observed to do in their teaching practice (Richardson, Anders, Tidwell, and Lloyd 1991).

Kuhn (1996) argued that inconsistent and unexplainable data are signs that a paradigm is no longer useful. I assert the cognitive paradigm itself is responsible for inconclusive results from research on professional development. The dualistic perspective does not allow us to explain why most participants in professional development do not adopt an Inquiry Identity and practice.

In Mark Windschitl, Jessica Thompson and Melissa Braaten's (2011) study, 35 % of the participants adopted what the authors termed "ambitious" science teaching practice, which is certainly an improvement on ten percent. Ironically, from my perspective, the eleven secondary science teachers in this study participated in practices consistent with the Discourse of Inquiry: engaging "in the collegial analysis of their students' work over 2 years...facilitated by tools that allowed them to situate their current repertoire of instruction within an explicit continuum of development". Reading the discussion and analysis, of course without access to the data corpus, I see clear evidence of discursive mediation of Inquiry Teaching (my term for what they call ambitious practice). However, the authors use the knowledge and beliefs paradigm, which is linear and does not recognize the role of reflexivity nor look at social construction of identity.

Teaching is *practice* and cognitive theories, which separate learning from context, are methodologically incommensurable with studying how identities mediate understanding of what it means to teach in a particular way. To the degree professional development is designed as a matter of individual cognition, which pays lip service to but in actuality ignores, the situated nature of teaching, I suggest it will continue to be problematic. I

propose that explicit attention to the mediating role of identities is crucial to the design of effective professional development for high school science teachers.

### Professional development in a social practice theory paradigm

#### Big-I identities and professional development

Marie's identity as an Inquiry Teacher at Bahia High School was mediated by personal, religious and professional identities. Ideas from PD shaped her understanding of her career trajectory and her sense of herself as an Inquiry Teacher. Practices entered *in person* the situated, embodied and storied world she inhabited with her students. In a sense, Marie Gonzalez existed as a nexus of social practices from the various social worlds she inhabited.

The notion that identity is practiced helps to make sense of the way Marie utilized the cultural resources at her disposal—including the Identity of Traditional Science Teacher which she learned by participating as a K-12 and undergraduate student. As time passed, the support of administrators and mentors, new ideas about practice from professional development, and friendships with teachers from outside her school allowed her to construct the Identity of Inquiry Science Teacher.

The Traditional Science Teaching Identity stands in opposition to the Inquiry Identity on several key points—including ideas about how to teach (transmission vs. constructivism), what counts as evidence of knowing science (memorization vs. conceptual understanding; assessment for grading vs. assessment of students' thinking), and what teacher should do (telling vs. facilitating)—to obtain the goals of teaching, that is, students learn science. Dorothy Holland and colleagues (2001) proposed that socially constructed identities provide tools for improvisation, and therefore agency. Individuals transform themselves and their communities. From this perspective, PD mediates for participants the formation of identities as a science teacher, and *transformation of identity* is the goal.

The difference between activities-based Traditional Teaching and genuine Inquiry teaching was not immediately clear to Marie as she struggled to transform her teaching. When interviewed in her ninth year of teaching, she observed:

[I]t all comes back down to, what is inquiry, what does it look like? And do people know what that looks like? Enough so they can actually do it in their classroom? Like sometimes, *I'm* questioning, am I doing inquiry?

Marie was one course short of finishing a master's program in science education at the same university where she got her credential. Gary, from the USI, was a part-time faculty member, and she had taken a class from him, which she felt was important to her practice of inquiry. This was one of the ten "professional developments" Marie identified as contributing to her practice (see Table 1).

Looking back, she constructed a coherent story out of the various pieces. Those that did not seem to have a great deal of impact on her practice she omitted from her narrative. Marie told the story of her pursuit of "professional developments" during an interview.

Vic: So, do you think it's [your teaching's] better than it's been before?

Marie: Yeah

Vic: What do you attribute that to?

Marie: Me knowing more

Vic: You knowing more. So is that from professional development of various sorts?

Marie: Basically I think it's all my professional developments up to now

Vic: Can you just tell me what they are?

Marie: Oh Lord...Oh, I can tell you the most significant ones... Well I think it all started with the USI trainings...Basically it kind of mushroomed from there...So I went to the USI training, and then everything, all my professional developments that have been meaningful have pretty much been based around inquiry...Yeah, so I would say the USI training that introduced me to inquiry. Then my whole training with *Science & Sustainability*...That whole curricular path...Where I get like curricular training, because they really, because they first introduced me to, I guess that sort of theme-based curriculum...

Vic: Okay. So the NACL is a third thing?

Marie: The third and probably the most comprehensive. None of the trainings had it all. The USI probably comes the closest. But I think they were still [unintelligible] as well as really getting teachers to really understand inquiry, I don't think *Science & Sustainability* did that very well. I don't know, there's just something, that, even the It's About Time people, I think—everyone really struggles with trying to get across, well what is inquiry...NACL probably was the best training that I've been to. But of course it's been over 3 years

The NACL to which she referred was the National Academy of Curriculum Leadership, designed by Biological Sciences Curriculum Study (BSCS) and funded by the National Science Foundation, which I also attended as a university representative. The purpose of the project was to assist districts in choosing and piloting their choice of the many already published NSF-sponsored inquiry curricula.

The NACL training consisted of 3 years of week-long summer institutes, with a two-day meeting during the school year. There Marie was introduced to Assessing Instructional Models, a structured method for evaluating curricula (NLIST 2004) as well as the Concerns Based Adoption Model (Horsley and Loucks-Horsley 1998). The first summer institute encouraged teachers to consider what inquiry is, and gave participants experiences with various types of inquiry, from open-ended to highly-structured. Throughout the 3 years, NACL continued to facilitate investigations into inquiry science teaching and textbooks. NACL pulled from a variety of other professional development resources, including Annenberg Foundation videos on mentoring. NACL, not intended for classroom teachers, was the only PD, besides her masters' class, which introduced principles of curriculum design such as coherence and conceptual development.

Marie identified Rodger Bybee's 5-E Learning Model (1997) as crucial to her understanding of inquiry.

Because I was basically trying to do inquiry but I had never seen the Learning Cycle before. And that was probably like three or 4 years ago. So I think that really allowed me to then understand the 5-E learning model, and then really understand what the It's About Time curriculum was all about... Because before, yeah, it was like getting prior knowledge and those types of things, but I never really thought about it, as far as how it was formatted, and why it was put together the way it was.

Prior to her introduction to the Learning Cycle, Marie had never considered that her curriculum was a structured sequence designed to develop students as thinkers about science, but had instead chosen hands-on activities to keep students engaged:

Marie: I mean, because when I first came into the classroom, you know, as a first-year teacher...I started out being a decent teacher. And I knew that lectures just bored



the hell out of me, so I didn't want to stand up lecturing in front of my classes. But I did it anyhow, but not all the time. I tried to do a lot of activities that were going to at least draw the kids in and make them interested... But it wasn't really in any organized way except for using the text structured the way it was

At the time we talked, Marie did not consider herself to be teaching through inquiry by just doing activities, and she labeled the other members of the department as highly traditional in spite of doing hands-on activities. She implied the understanding students' thinking as enabled by the 5-E Learning Model was crucial. I suggest it provided a heuristic, a rule of thumb, which Marie used to keep herself on track and to remind her of the kind of science teacher she wanted to be. I further conclude that the cognitive apprenticeship model provided by West Ed (2007) was equally transformative because it provided her with tools to understand students' thinking.

Marie: The Reading Apprenticeship stuff that I do. That's been a real key

Vic: I see you paying a lot of attention to that

Marie: Um hmm. So before I never really thought about it, but it makes so much sense, you know, and so I think when I read, I try to read through my kids' eyes, like, how are my kids going to perceive things? And so it makes me look at everything differently when I think about how I'm going to present it to my students. Like the *Science & Sustainability* reading I think is just way too, it's just here [gestures above her head]. Because kids don't stop and try to conceptualize things as they read, and if they even are trying, they may have the wrong conception, because they have no background information

Although Marie here spoke about Reading Apprenticeship (RA) in a compartmentalized way, limiting her comments to students' reading of science text, I observed a significant change in her practice between the first and second years of observation. By the middle of the second year, she had attended many RA professional development sessions. I now observed her to engage in extended public dialogues and discussions in which she elicited and expanded students' ideas about content. For example, she spent 30 min listening to and asking probing questions about students' short written responses to the prompt, "What is soil?" Students' ideas and questions were recorded on poster paper and hung about the room, and referred to as the two-week unit progressed.

### Learning from professional development

Marie spoke of ten major sources of in-service professional training from 1994 through 2004, as outlined in Table 1. For the entire 10 years, she also attended periodic mandatory faculty meetings and school-wide staff development days, as well as several other teacher training institutes, which she did not consider particularly worthwhile, because they did not help her understand what inquiry is.

From the standpoint of a professional developer and/or curriculum designer, many interesting ideas emerge from Marie's chronology. In the first place, she took a very long time to understand what inquiry was, perhaps seven or eight years. By the time of the study, Marie had arrived at a very broad working definition, that inquiry consisted of students "investigating on their own." In her classroom I observed many different types of inquiry, including students investigating what textbooks had to say. For example, she asked a chemistry class to compare the "scientific methods" they used in an open-ended investigation with the description of the scientific method in the first chapter of their chemistry

text. The students concluded they were essentially similar, but that the investigation they carried out themselves didn't go in the same order. The students found this exercise eye-opening, the rather dull textbook coming to life, because they had experienced the process of developing questions and systematically investigating them.

The curriculum implementation workshops she attended intentionally followed the cognitive paradigm for providing professional development, as exemplified in Loucks-Horsley et al.'s (2009) authoritative compendium of professional development in science and mathematics. (The first edition was published in 1998, and Marie mentioned it as her model for running the department.) The theoretical framework for Loucks-Horsley's ideas is knowledge and beliefs supporting effective professional development (2009, p. 51). Marie assessed her attempts to use the knowledge and beliefs framework in the professional development she planned for the department as unsuccessful.

Marie was herself, having become department chair the year before I began this ethnography, attempted to improve the quality of teaching in her department using the ideas of the cognitive paradigm. My theories of professional development would predict little benefit from such an approach. (I did attend, record, and analyze the talk at two of these meetings; see Deneroff 2012.) Her efforts to encourage talk about students' learning and the best ways of teaching had been frustrating:

So my whole idea is that I really liked a lot of the things that were in Susan Loucks-Horsley's book and my idea is to get, I think the whole reason I went off of that, is that we have all these teachers that are all at these different levels of what they need, and it's almost virtually impossible to have a good meeting with every single person present at all of these different levels, because then you've got people like X and like Y, who, all they want to do is sit down and talk about their bad students. Right? So no matter what discussion is on the table, they will always come back to talk about that. Because that's their reality, right?

Marie did seem to have an instinctive understanding that the cultural world inhabited by X and Y did not afford their learning of inquiry. She attributed this to their personal deficiencies as teachers, not to practices of teaching mediated by identity. This is reinforced in Loucks-Horsley et al. (2009) cognitive paradigm aimed at changing teachers' knowledge and beliefs.

### **What would professional development based on social practice theories look like?**

After my first year of graduate school, I was hired to facilitate professional learning for a group of non-volunteer urban high school science teachers, who were very unhappy with being forced to attend. After struggling for a week, I buttonholed one of my professors, and asked whether she had any suggestions. "What's your theory of learning?" she replied. At that point in my studies I knew I was supposed to answer "sociocultural," but actually had little idea what that meant in terms of designing learning environments. I did not see how her response was of any help. It now seems to me to be the most important question in considering how to design professional development.

The literature on professional development reveals a consensus that teacher learning for inquiry science teaching requires a great deal of time, and intensive support in the form of regular, ongoing follow-up as well as mentoring (Hawley and Valli 1999). However, the results of professional development constantly show inconsistent, small benefit in terms of long-term transformation of practice. Even when PD incorporates research-based elements,

which is rare because of the cost and time commitment, the results are unimpressive. Tal, Krajcik and Blumenfeld (2006), mentioned previously, counted 3 success stories out of a group of 25 Chicago science teachers, which does not diminish their accomplishment, but is still not acceptable, to my mind.

Transformation of science teaching so that all students have access to high-quality instruction is urgent. Marie told me the Science Department failure rate at Bahia High School was 60 %. That it can be done is demonstrated by occasional outliers, such as the AP Chemistry teacher described by Lave (1996), who consciously used SPT to transform urban students into high-achieving chemistry learners.

### Resolving contradictions with the lens of SPT

I argue that the cognitive paradigm, used by most researchers, does not ask, nor try to answer, questions that will lead to the design of more effective professional development. In part this is because of narrow, traditional conceptions of teacher professional learning, and of learning in general. Lave argues the cognitive paradigm “naturalize[s] and underwrite[s] divisions of social inequality in our society” (1996, p. 149). This Discourse is grounded in the assumption that it is natural for some individuals to be “smart” and others “not smart,” just as it is natural for some teachers to be “with-it” and some (most) to be “not with-it.” Lave goes on to wonder, “How is the objective world socially constituted, as human beings are socially produced, in practice?” (1996, p. 154). I would further ask, how does the socially constituted world of schooling produce a science teaching workforce of only a few who really challenge students and prepare them for participation in a technologically advanced society?

In this paper I have attempted to represent how Marie Gonzalez’s Inquiry Identity reflexively mediated her participation in professional development in order to create her self as an exemplary urban high school inquiry teacher. SPT provides a cogent framework for understanding how human beings become who they are through participating in culture, and how practiced identity in turn mediates participation. At the beginning of her career, Inquiry was a new Discourse for Marie. The Inquiry Identity grew over time, as “Identity development occurs as one brings current beliefs about what she cares for, is competent with, and is knowledgeable about to bear on participation in the practices of this new Discourse” (Luehmann 2009).

Teachers such as Marie engage in struggle to understand inquiry and what it means for practice. She was not unique in expressing difficulty grasping what inquiry is; one of our group, sitting at a table at one of the NACLE meetings, burst out during a lull in conversation, “I don’t think I even *know* what inquiry is!” (Deneroff, Sandoval and Franke 2002). I infer the difficulty is not that Marie or Samantha did not understand the meaning of the word “inquiry,” but rather she did not see who she would be in such a classroom. What does it mean to be a person who facilitates students in answering their own questions? What does it feel like to be in her skin? I propose that effective PD must focus on creating a space in which inquiry is looked at as a socially-constructed Discourse.

Participation in a Discourse of Inquiry requires major reshaping of teachers’ ideas about who they are and what it means to be a science teacher. In the cognitive paradigm, teachers identities are not seen in this mediating role. Using social practice theories, the major task of professional development for high school science teaching is to consciously address the development of an Inquiry Identity.

Researchers have argued for the mediating power of identity. Noel Enyedy, Jennifer Goldberg, and Kate Muir (2005) showed the ways in which three science teachers’ pre-

existing identities interacted with their implementation of new curriculum. However it is not clear from their study how professional development could be designed to facilitate reflexive transformation of identity within professional learning environments.

### Research questions about professional development using the SPT paradigm

I suggest that the occasional and limited successes of cognitive-paradigm programs are accidental, in the sense the explanations generally are not based on principle and theory. Perhaps better said, the cognitive paradigm is incommensurable with understanding the embodied, situated and storied nature of teaching practice, and therefore not consistently useful in transforming it. Undoubtedly mentoring and long-term participation sometimes lead some teachers to use inquiry-based professional development as a space for authoring an Inquiry Identity, but Identity is not deliberately attended to by providers. In order to consciously create more consistent learning, a new set of questions comes to mind:

What are the assumptions about learning and learners which teachers need to examine in order to identify as Inquiry Teachers?

How can teachers understand inquiry as a paradigm rather than a teaching strategy?

How can professional development be grounded in practice in such a way as to be relevant to the situated, embodied and storied work of science teaching?

Beth Warren and Ann Rosebery (2011) used inquiry science learning experiences for adult learners, video analysis of teachers' own practice, and group discussion about dilemmas of practice over several years in their professional development design. The purpose and result of their collaborative work was that teachers showed evidence of adopting the perspective that marginalized, underrepresented students they had previously judged as underprivileged were in fact competent learners. I infer Warren and Rosebery's (2011) work, which was developed using a SPT framework for child learners, extended the same framework to the design for adults.

I propose, using Warren and Rosebery's model (2011) that a movement to Inquiry Identity starts with urban teachers unpacking assumptions about their own students and how they learn, and then constructing a different idea of what it means to be a science teacher, and a different understanding of the possibilities for science learning. Marie sought out nine years of sustained professional development in ten projects in order to create a vision of inquiry within her own classroom. Transformational practices which altered Marie's trajectory, and which were apparent in her teaching, were the use of the 5-E Learning Model as a heuristic, and professional development in the practices of Reading Apprenticeship (RA). Both the 5-E Model and RA gave Marie a way of understanding students' thinking, and thus to transform her Identity.

**Acknowledgments** This work was supported in part by a grant from the Arthur Vining Davis Foundations

### References

- Beijaard, D., Meijer, P. C., & Verloop, N. (2004). Reconsidering research on teachers' professional identity. *Teaching and teacher education*, 20(2), 107–128. doi:10.1016/j.tate.2003.07.001.
- Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, 33(8), 3–15. doi:10.3102/0013189X033008003.
- Bourdieu, P., & Passeron, J.-C. (1977). *Reproduction in education, society and culture*. London: Sage.
- Bybee, R. W. (1997). *Achieving scientific literacy*. Portsmouth, NH: Heinemann.
- Cohen, E., & Lohan, R. (Eds.) (1997). *Working for equity in heterogeneous classrooms: Sociological theory in practice*. New York: Teachers College Press.

- Colyar, J. (2009). Becoming writers, becoming writing. *Qualitative Inquiry*, 15, 421–436. doi:10.1177/1077800408318280.
- Crawford, B. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching*, 44, 613–642. doi:10.1002/tea.20157.
- Deneroff, V. (2004). *Professional development, practice, and teacher discourse communities: how an urban high school science teacher negotiated inquiry practice*. (Unpublished doctoral dissertation.) University of California, Los Angeles.
- Deneroff, V. (2012). *A social practice theory/Vygotskian theoretical framework for understanding high school science teachers' talk in professional development*. Paper presented at the Annual Conference of the National Association of Research in Science Teaching, April 27, 2012. Indianapolis, IN.
- Deneroff, V. M., Sandoval, W. A., & Franke, M. L. (2002). *Learning the language of inquiry: How in-service high school science teachers understood themselves as listeners*. Paper presented at the Annual Meeting of the American Educational Research Association. New Orleans, April 2002.
- Dewey, J. (1916). *Democracy and education*. Accessed at <http://www.gutenberg.org/files/852/852-h/852-h.htm>, September 12, 2008.
- Duschl, R. A. (1990). *Restructuring science education: The importance of theories and their development*. New York: Teachers College Press.
- Enyedy, N., Goldberg, J., & Muir, K. (2005). Complex dilemmas of identity and practice. *Science Education*, 90(1), 68–93. doi:10.1002/sce.20096.
- Fennema, E., & Franke, M. L. (1992). Teachers' knowledge and its impact. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 147–164). New York: Macmillan Library Reference.
- Fishman, B. J., Marx, R. W., Best, S., & Tal, R. T. (2003). Linking teacher and student learning to improve professional development in systemic reform. *Teaching and Teacher Education*, 19(6), 643–658. doi:10.1016/S0742-051X(03)00059-3.
- Franke, M. L., Fennema, E., Carpenter, T., Ansell, E., & Behrend, J. (1998). Understanding teachers' self-sustaining generative change in the context of professional development. *Teaching and teacher education*, 14(1), 67–80. doi:10.1016/S0742-051X(97)00061-9.
- Gee, J. (1996). *Social linguistics and literacies: Ideology in discourses*, 2d. New York: Routledge Falmer.
- Gilbert, A., & Yerrick, R. (2001). Same school, different worlds: A sociocultural study of identity, resistance and negotiation in a rural, lower track science classroom. *Journal of Research in Science Teaching*, 38, 574–598. doi:10.1002/tea.1019.
- Gladwell, M. (2008). *Outliers: The story of success*. New York: Little, Brown & Company.
- Goodall, H. L. (2006). *Writing the new ethnography (ethnographic alternatives)*. [Kindle version]. Washington DC: Altamira Press.
- Harding, S. (1998). *Is science multicultural? Postcolonialisms, feminisms, and epistemologies*. Bloomington: Indiana University Press.
- Hashweh, M. Z. (2005). Teacher pedagogical constructions: A reconfiguration of pedagogical content knowledge. *Teachers and Teaching*, 11, 273–292. doi:10.1080/13450600500105502.
- Hawley, W. D., & Valli, L. (1999). The essentials of effective professional development: A new consensus. In G. Sykes & L. Darling-Hammond (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 127–150). San Francisco: Jossey-Bass.
- Hill, H. (2011). *The nature and effects of middle school mathematics teacher learning experiences*. Teachers College Record, 113, 205–234. Accessed September 8, 2012 from <http://www.tcrecord.org> ID Number: 16005.
- Holland, D., Lachicotte, W., Skinner, D., & Cain, C. (2001). *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press.
- Horsley, D. L., & Loucks-Horsley, S. (1998). CBAM brings order to the tornado of change. *Journal of Staff Development*, 19(4), 17–20.
- Kuhn, T. S. (1996). *The structure of scientific revolutions*. Chicago: University of Chicago Press. doi:10.7208/chicago/9780226458106.001.0001.
- Lave, J. (1996). Teaching, as learning, in practice. *Mind, Culture and Activity*, 3(3), 149–164. doi:10.1207/s15327884mca0303\_2.
- LeCompte, M. D., & Schensul, J. J. (1999). *Ethnographer's toolkit* (Vol. 1). Walnut Creek: Altamira Press.
- Loucks-Horsley, S., Stiles, K. E., Mundry, S., Love, N., & Hewson, P. W. (2009). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin Press.
- Luehmann, A. L. (2009). Accessing resources for identity development by urban students and teachers: Foregrounding context. *Cultural Studies of Science Education*, 4, 61–66. doi:10.1007/s11422-008-9139-4.

- Martin, K. (1998). Becoming a gendered body: Practices of preschools. *American Sociological Review*, 63(4), 494–511. doi:10.2307/2657264.
- NLIST. (2004). *Assessing instructional materials for inquiry: A workshop*. Web page Accessed March 19, 2007. <http://www.nlistinquiryscience.com/inquiry/>.
- Reckwitz, A. (2002). Toward a theory of social practice: A development in culturalist theorizing. *European Journal of Social Theory*, 5(2), 245–265. doi:10.1177/13684310222225432.
- Richardson, L. (2008). Writing: A method of inquiry. In L. Richardson & E. A. S. Pierre (Eds.), *A method of inquiry* (pp. 923–948). Thousand Oaks, CA: Sage Publications, Inc.
- Richardson, V., Anders, P., Tidwell, D., & Lloyd, C. (1991). The relationship between teachers' beliefs and practices in reading comprehension. *American Educational Research Journal*, 28(3), 559–586. doi:10.3102/00028312028003559.
- Rogoff, B. (1994). Developing understanding of the idea of communities of learners. *Mind, Culture, and Activity*, 1(4), 209–229.
- Sfard, A., & Prusak, A. (2005). Telling identities: In search of an analytical tool for investigating learning as a culturally shaped activity. *Educational Researcher*, 34(4), 14–22. doi:10.3102/0013189X034004014.
- Stetsenko, A. (2008). From relational ontology to transformative activist stance on development and learning: Expanding Vygotsky's (CHAT) project. *Cultural Studies of Science Education*, 3(2), 471–491. doi:10.1007/s11422-008-9111-3.
- Tal, T., Krajcik, J., & Blumenfeld, P. (2006). Urban schools' teachers enacting inquiry-based science. *Journal of Research in Science Teaching*, 43, 722–745. doi:10.1002/tea.20102.
- Tobin, K., & Gallagher, A. (1987). What happens in high school science classrooms? *Journal of Curriculum Studies*, 19, 549–560.
- Van Driel, J. H., Verloop, N., & De Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of research in Science Teaching*, 35(6), 673–695. doi:10.1002/(SICI)1098-2736(199808)35:6<673:AID-TEA5>3.0.CO;2-J.
- Warren, B., & Rosebery, A. (2011). Navigating interculturality: African-American male students and the science classroom. *Journal of African American Males in Education*, 2(1). Accessed June 8, 2012 at <http://journalofafricanamericanmales.com/wp-content/uploads/downloads/2011/03/Navigating-Interculturality.pdf>.
- Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge: Cambridge University Press.
- West-Ed. (2007). *Leadership institute in reading apprenticeship*. <http://www.wested.org/cs/we/view/serv10>. Web page Accessed June 10, 2007.
- Windschitl, M. (2004). Folk theories of "inquiry": How preservice teachers reproduce the discourse and practices of an atheoretical scientific method. *Journal of Research in Science Teaching*, 41(5), 481–512. doi:10.1002/tea.20010.
- Windschitl, M., Thompson, J., & Braaten, M. (2011). Ambitious pedagogy by novice teachers: Who benefits from tool-supported collaborative inquiry into practice, and why? *Teachers College Record*, 113(7), <http://www.tcrecord.org> ID Number: 16061, Accessed 1/5/2011 10:09:03 PM.

## Author Biography

**Victoria Deneroff** is an Associate Professor of Education at Georgia College & State University in Milledgeville, Georgia. She is actively works for equity and social justice in STEM education. Her research focuses on the discursive construction of science teachers' identities, and the ways identity mediates practice.

Cultural Studies of Science Education is a copyright of Springer, 2016. All Rights Reserved.