

*Research Article***“What Comes to Mind When You Think of Science? The Perfumery!”:
Documenting Science-Related Cultural Learning Pathways
Across Contexts and Timescales**Leah A. Bricker¹ and Philip Bell²¹*School of Education, University of Michigan, 610 E. University Avenue, Office #4047, Ann Arbor, Michigan 48109*²*College of Education, University of Washington, Seattle, Washington**Received 11 June 2013; Accepted 25 November 2013*

Abstract: In this paper, we explore the details of one youth’s science-related learning in- and out-of-school at the time of her participation in an ethnography of youth science and technology learning across contexts and over time. We use the Cultural Learning Pathways Framework to analyze the youth’s interests, and the related sociocultural, historical, material, and affect-laden practices in which she and her family participated. The following question guided our analysis: How do everyday moments—experienced across settings, pursuits, social groups, and time—result in scientific learning, expertise development, and identification? We found that this youth’s interest in various aspects of the sciences was years in the making, embedded in situated events that were part of a space–time continuum bound by passion for the practices involved, influenced by specific cultural practices, and explored with the help of close family collaborators. We also found that school science activity in which the youth in question participated both supported and could have potentially constrained her science-related cultural learning pathways. © 2013 Wiley Periodicals, Inc. *J Res Sci Teach* 51: 260–285, 2014

Keywords: culture and science learning; learning pathways; learning in- and out-of-school; ethnography

Youth engage in a wide variety of science, technology, engineering, and mathematics (STEM)-related activity across the settings of their lives, and thus participate in, and learn about, disciplinary practices and ideas both in and out of school (see NRC, 2009). Like all types of learning, STEM-related learning is influenced by such entities as values, cultural norms, identities, interests, and ideologies, although we contend that it is rare that analyses of STEM-related learning explore intersections among these constructs, and their relationship to learning about STEM (cf. Banks et al., 2007). Additionally learning is mediated by a vast array of sociomaterial resources and practices that are often highly semiotic in nature (e.g., Vygotsky, 1978a, 1978b), but without examining their function as a collection or a set of learning supports across settings and over time, it is difficult to ascertain their specific roles in any given STEM-related learning narrative.

We have discussed elsewhere (Bricker & Bell, 2012) that certain contexts, school being chief among them for many youth, are sites of disruption and frustration in relation to otherwise

Contract grant sponsor: National Science Foundation; Contract grant number: SBE-0354453.

Correspondence to: L.A. Bricker; E-mail: lbricker@umich.edu

DOI 10.1002/tea.21134

Published online 23 December 2013 in Wiley Online Library (wileyonlinelibrary.com).

sophisticated STEM-related learning and expertise that youth are developing in a plethora of other settings. Nasir, Rosebery, Warren, and Lee (2006) describe this phenomenon as such:

Often, people can competently perform complex cognitive tasks outside of school, but may not display these skills on school-type tasks. This finding indicates the importance of understanding learning in out-of-school settings, and how to build on this learning to support learning in school. (p. 491)

This image is reminiscent of Dewey's questions about the legitimacy of separating the school context from all others with respect to the type of knowledge and practices embedded in situ (cf. Dewey, 1900/1902/1990). How can we as science educators help construct better bridges between STEM-related in- and out-of-school learning experiences and opportunities for youth?

For the past decade, we have been interested in examining youths' STEM-related learning pathways and ecologies (see Barron, 2006; Bell, Bricker, Reeve, Zimmerman, & Tzou, 2012a), as they are situated both in and out of school. Lave and Wenger (1991) remind us that ". . . learning is not merely situated in practice—as if it were some independently reifiable process that just happened to be located somewhere; learning is an integral part of generative social practice in the lived-in world" (p. 35). Therefore, to truly understand STEM learning, we argue that it is critical to understand the sociocultural and historical milieu associated with the STEM-related social practices of which learning is part and parcel. To that end, we explicated the theoretical underpinnings of a framework we titled the Cultural Learning Pathways Framework (Bell, Tzou, Bricker, & Baines, 2012b), and argued that it is rare to have accounts of the same person's STEM-related learning over significant periods of time and across his/her contexts of participation.

Yet, we argue that these accounts are exactly what are needed in order to better understand aspects of youths' STEM-related learning (e.g., Bell et al., 2012a; Bricker & Bell, 2012; Nasir, 2000; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001), as well as to leverage the details and nuances of these learning pathways in the design of school science related learning environments (e.g., Bang, Medin, Washinawatok, & Chapman, 2010; Calabrese Barton, 2003; Rosebery, Warren, Ballenger, & Ogonowski, 2005; Tzou, Bricker, & Bell, 2007). Assuming that the science education community considers youths' experiences, interests, cultural practices, and linguistic patterns, for example, as part of their prior knowledge (see Bricker, Reeve, & Bell, in press), and that the field values building on learners' prior knowledge during school science instruction (see Bransford, Brown, & Cocking, 2000), how do we, as science educators, learn about and characterize youths' STEM-related trajectories across contexts and timescales so that we can help build better STEM-related learning bridges?

In this paper, we explore the details of one youth's science-related learning as part and parcel of the leading sociomaterial practices (practices that are dependent not only on people and their interactions, but also on the material features of their activity), and interests in her life at the time of her participation in an ethnography of science and technology learning across settings and over time (Bell et al., 2012a). We use the Cultural Learning Pathways Framework to analyze the sociocultural, historical, and material practices in which she and her family (chiefly, her mother) participated, and how these practices responded to and shaped her interest in STEM-related domains and activities. The following question guided our analysis: How do everyday moments—experienced across settings, pursuits, social groups, and time—result in scientific learning, expertise development, and identification? In what follows, we explicate the Cultural Learning Pathways Framework and related theoretical positions. We then discuss the methods and analytic processes we used to generate this analysis, and we explore our findings.

Theoretical Framework

The Cultural Learning Pathways Framework (Bell et al., 2012b) is our attempt to explain how we might better understand where, how, what, why, and with whom people learn (and if learning is impeded, why that might be the case). We seek to understand how individuals and groups learn in ways that are meaningful to them with respect to their activity in various contexts, over time, and as related to culturally influenced value systems. We consulted social practice theory (Holland & Lave, 2009) that examines the relational characteristics of people, practice, and historical trajectories, a “history in person” conceptualization (although social practice theory pays particular attention to institutionalized conflict, tension, and difference, which are not the focus of our analysis). As Holland and Lave note, social practice theory “. . .emphasizes the importance of cultural activities in framing human cognition and social activity, but goes on to inquire into how persons develop in practice. . .it focuses on how history-in-person takes shape in local practice interpreted according to cultural activities” (p. 5). When constructing the Cultural Learning Pathways Framework, we also drew heavily on the concepts of life-long learning (learning across one’s lifespan), life-wide learning (learning across the various contexts that people navigate), and life-deep learning (learning as connected to personal and cultural value systems; see Banks et al., 2007; Bricker et al., in press).

Additionally, the Cultural Learning Pathways Framework is strongly influenced by Ole Dreier’s theory of persons (2008, 2009), which he uses to examine the structural nexus of social practice in which people, activity, and artifacts are linked within and across contexts. Dreier’s image is that of a web of contexts, in which people-and-objects-in-activity are situated, as well as navigating through and across. Gee’s (2011) notion of a practice is useful here, a “. . .socially recognized and institutionally or culturally supported endeavor that usually involves sequencing or combining actions in certain specified ways” (p. 17). Dreier is particularly interested in the sociomaterial arrangements within and across contexts that either support or inhibit people’s agency as they participate in practices that are embedded in these various contexts. Drawing on social practice theory, life-long, wide, and deep learning, and a theory of persons, the Cultural Learning Pathways Framework is undergirded by images of learning as social, situated (Lave & Wenger, 1991), and distributed (e.g., Hutchins, 1995). Figure 1 is a diagram of the various components of the Cultural Learning Pathways Framework.

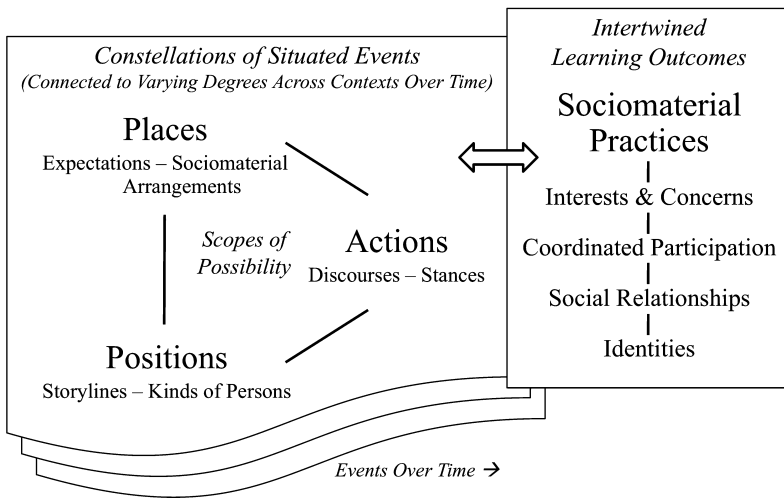


Figure 1. Cultural Learning Pathways Framework.

The right side of the framework highlights how sociomaterial practices are influenced by (and influence in their own right) learners' interests, concerns (e.g., a real or perceived injustice), co-ordinated participation with others in order to accomplish activity, the texture of various social relationships that are part of the sociomaterial practices, and learners' identities. We align ourselves with Gee (2011) in terms of our thinking about identity—"...different ways of being in the world at different times and places for different purposes" (p. 3). Consistent with social practice theory, and as noted by Tan, Calabrese Barton, Kang, and O'Neill (2013), identity is not simply a designation. Rather, "...identities take shape as one engages in the practices of a community, and learns the ways of talking, knowing, doing, and being of that community" (p. 1144). Lave and Wenger (1991) remind us that learning and identity are intertwined.

...learning...implies not only a relation to specific activities, but a relation to social communities—it implies becoming a full participant, a member, a kind of person...Activities, tasks, functions, and understandings do not exist in isolation; they are part of broader systems of relations in which they have meaning... Viewing learning as legitimate peripheral participation means that learning is not merely a condition for membership, but is itself an evolving form of membership. We conceive of identities as long-term, living relations between persons and their place and participation in communities of practice. Thus identity, knowing, and social membership entail one another. (p. 53)

Identities are situated in, related to, and shaped by (as well as shape) sociomaterial practice, and therefore, are part and parcel of learning-in-practice.

The right side of the framework focuses on specific concepts that represent both learning influences (i.e., how interests and concerns and/or identities influence engagement in sociomaterial practices), and outcomes (i.e., how sociomaterial practices involve specific forms of coordinated participation and shape social relationships). We claim that these influences can initiate sustained, deep participation in different activities (domain-related or otherwise), and this happens through interest stabilization (Bell et al., 2012b). For example, a youth's interest in gaming can serve as a driving force for long-term STEM-related learning—and also an outcome of participation in different gaming genres (cf. Barron, 2006; Bricker & Bell, 2012; Hidi & Renninger, 2006). In addition, we identify forms of participation in (cf., Ito et al., 2010), relationships with others (cf. Bruner, 1996), and socially constituted identities (e.g., Wortham, 2004, 2005) as being vital to learners' desire to enter into, and then navigate, the structural nexus of any social practice. To be clear, outcomes are not always positive from the perspective of the learner. For example, youths' interest in local environmental issues may be a catalyst for participation in an after school environmental club, but youth agency within that context might be stifled (knowingly or unknowingly) by club organizers, or youths may be marginalized as their identities are recast in ways that reflect societal stereotypes (see Tzou & Bell, 2012).

The left side of the framework highlights our claim that learners' influences and outcomes represented on the right side of the framework impact, and are impacted by, what we call "constellations of situated events," often linked across contexts and time. As Leander and McKim (2003) discuss, contexts and time are not static constructions in, or during which, activity happens. Rather, activity helps construct space and time, and thus, space and time are relational constructs. The notion of a "learning pathway" is a space-time metaphor (cf. Gentner, 2001).¹ Therefore, as part of examining youths' science learning across contexts and timescales, we wish to analyze how various constellations of situated science-related events help construct space-time

relationships, instead of solely analyzing only the affordances of any one context and/or the amount of time spent on any particular task.

Of critical importance is how a learner is positioned within contexts and as part of participation in various activities (e.g., positioned as someone capable of doing STEM-related work). People are assigned positions, using “storylines” that others (or they themselves) construct in relation to images of the “kinds of persons” socially available in any context. As Gonsalves, Rahm, and Carvalho (2013) note, “Actors learn about accepted modes of belonging (was of participating, storylines, subject positions). . . through participation in activities (centrally or peripherally). . .” (p. 1071). Assigned positions carry certain rights and responsibilities that those assigned can either accept or reject (e.g., Harré, Moghaddam, Cairnie, Rothbart, & Sabat, 2009; Holland & Leander, 2004). As depicted in the framework, scopes of possibilities are afforded and/or constrained by context, positioning, and learner action and agency within practice. Possibilities are also afforded and/or constrained by power and those who have the power to arrange the sociomaterial activity (and thus, aspects of space–time relationships), assign rights and responsibilities, etc. This often ensures an unequal distribution of learning opportunities and resources within the structural nexus of social practice (see Dreier, 2008).

We conceptualize the connections between the left and right side of the framework through identity-positioning relationships. As Johnson, Brown, Carlone, and Cuevas (2011) note, “Authoring involves identity-related performances of self for others. The “others” . . . in turn legitimate the credibility of the performance by recognizing the person as . . . one of ‘their own’” (p. 344), or one of a certain type of person (e.g., scientific). Carlone and Johnson’s (2007) identity-related model is relevant to this discussion. The three related and overlapping parts of the model are competence, performance, and recognition. Clearly, many instantiations of this model exist. For example, a learner might view herself as competent, and perform accordingly, but important others in the community (e.g., teachers) do not recognize her competence.

In sum, how do people learn to be, act, and know as part of sociomaterial practices taking place within and across situated events? How do people author their learning pathways, and have them shaped, through space and over time? Learners construct and navigate multiple learning pathways within the course of their lives. Some are sustained over years or lifetimes, while others may die out in favor of participation in other situated events, as part of other learning pathways. The case we showcase in this paper explicates the details of various events and related sociomaterial practices that one youth participated in and considered related to science. We contend that these events constituted multiple, yet intertwined, science-related learning pathways, with one consistent feature—a focus on the *doing* of science as part of participation in various scientific practices. We turn now to a discussion of how we conceptualize scientific practice.

Scientific Practice

In order to better understand how sociomaterial practices are utilized in the sciences and in engineering fields, we draw heavily on the science studies literature, especially the literature that theorizes about scientific practices. Science studies are an interdisciplinary field encompassing the philosophy of science, anthropology of science, sociology of science, rhetoric of science, history of science, etc. (see Sismondo, 2010). In the analysis we present in this paper, the features of the cultural learning pathways we examine are directly related to the focal youth’s images of, and practices associated with, scientific disciplines. Therefore, we turn to the science studies literature as a way to draw parallels among professional scientific practices and this youth’s practices as embedded in her activity across the settings she frequented during the time of her participation in our research.

Rouse (1995) argues that scientific practices are, "...patterns of situated activity... [including] the material setting of activities within the conception of practice... [practices] are dynamic and temporally extended, since their patterns only exist through continuing reenactment" (p. 397). Additionally, Lynch (1993) contends that:

...we should forget "knowledge" as an adequate way of formulating the entire "content" of science. Much of what goes under the heading of "knowledge" in science studies can be decomposed into embodied practices of handling instruments, making experiments work, and presenting arguments in texts or demonstrations... observation, representation, replication, measurement, and the like are "locally organized." (pp. 310–311)

The field of science education heavily values engaging youth with a variety of specific scientific practices (e.g., learning to ask testable questions, learning to construct evidence-based arguments, learning to analyze and interpret data), and this engagement is now a leading goal of science education (NRC, 2012; NGSS Lead States, 2013). Although this goal is not new (see, e.g., Schwab, 1960), the release of the *K-12 Framework for Science Education* (NRC, 2012), and the *Next Generation Science Standards* (NGSS Lead States, 2013) places renewed emphasis on the role that participating in specific scientific practices plays in learning important scientific ideas, identifying with professional science, making scientific-related decisions, and the like. The goal of this paper is to concretize the Cultural Learning Pathways Framework by layering in specific details, as we previously noted, from a case study stemming from one youth's science-related interests, and her engagement in practices that she began to count, over time, as scientific. Before explicating the details of the case, we turn to a discussion of our methods and the analytic techniques we used to make sense of our data.

Methods and Analysis

The data we use in this analysis stem from an ethnography of youth science and technology learning across settings timescales that we conducted from January, 2006 through June, 2008 (see Bell et al., 2012a). Youth participants in the ethnography were living with their families and going to school in a large city in the Pacific Northwest. Participating families were multilingual, multiethnic, and representative of the socioeconomic spectrum found in the United States. Many had immigrated to the United States. We used the following methods in our research: (a) observation and participant observation in school, homes, and various community settings, (b) clinical and ethnographic interviews, (c) document collections, (d) surveys, and (e) self-documentation tasks focusing on specific themes like images of science and technology (cf. Clark-Ibanez, 2004; Glesne, 1999; Reeve & Bell, 2009). During our research, we visited the homes and other settings (e.g., school, museums, neighborhoods) associated with 13 focal participants (4th and 5th graders at the time of their enrollment in the study) approximately twice a month for at least 1 year. Each visit was video- and audio-recorded, and also chronicled with digital photographs and field notes. In settings where video-recording was not allowed or feasible (e.g., community or school contexts in which not everyone was consented, and/or settings that prohibited the use of recording devices), we took detailed field notes to record applicable events.

Participants and Settings

For this analysis, we utilized a case study approach in order to fully explicate examples of science-related cultural learning pathways (cf., Yin, 2009). We chose to highlight the case of one focal participant, Brenda Joseph.² Brenda's mother, Stella, immigrated to the United States from Haiti as a teenager with her mother and siblings. Stella adopted Brenda from Haiti when Brenda

was a baby. The majority of data collection with the Josephs took place from January, 2006 through June, 2008 (when Brenda was in 4th, 5th, and 6th grade). Thus, we were privy to a snapshot of Brenda's developing science-related learning pathways, and the associated situated events. During the time that Brenda and Stella were enrolled in the ethnography, we visited the family 31 times for a total of 84 hours. These visits took place in the family's home, in museums, in Stella and Brenda's neighborhood, and as part of events, such as Puppygarten (a dog training class). In addition, we observed Brenda for a total of 85 hours in her 4th grade classroom and 157 hours in her 5th grade classroom (we did not observe Brenda in school once she went to middle school in the 6th grade). Data sources for this analysis include *video- and audiotape* of observations (when sanctioned by the setting) and interviews, *field notes* of observations in all settings, *digital photographs* taken by Brenda and by us, and *documents and other artifacts* associated with Brenda's science and technology learning, and other developing areas of expertise.

Brenda's case exemplifies the intricacies, nuances, and complexities associated with the development of science-related cultural learning pathways. While all of the youth enrolled in the study possessed learning narratives tied to activity, affiliated others, identities, and so on, for this analysis, we chose to highlight Brenda's learning narrative because it is directly related to science. Several other participants had rich technology and engineering-related learning narratives, for example (see Bricker & Bell, 2012 for a technology-related case), and still others had rich learning narratives specific to other types of activity (e.g., learning narratives related to the development of sporting expertise). It is an empirical question, but uncovering these narratives and then actively and thoughtfully leveraging them as part of science education in schools could have enormous learning implications.

Data Analysis

Consistent with ethnography, we sought to formulate a thick description of Brenda's science-related cultural learning pathway (cf. Geertz, 1973). We formulated the account that we present in this paper from 2 years of data collection, as well as recent conversations with Brenda. After each visit with the Josephs, we logged specific details about the visit (e.g., date, time spent in the field, location[s] of field work, summary of field work, connections with other field work episodes, numbers of video tapes shot, number of audio files recorded, number of digital pictures taken). Additionally, we content-logged videotapes and audio files associated with each visit. This process involved viewing the content of each tape and describing its content in a Word document (cf. Jordan & Henderson, 1995). We did this so that we could make more informed decisions and choices about future data collection, and so that we could follow-up with Brenda and Stella if we needed to better understand an event, a conversation, an artifact, etc. We transcribed data segments of interest and analyzed the transcripts, video records, field notes, and photographs for themes related to our theoretical framework, but also as emerging directly from our data (Glaser & Strauss, 1967). Data segments of interest included all data segments that appeared related to Brenda's science-related cultural learning pathways, the details of which emerged through our fieldwork in school with Brenda, and also in the other settings she frequented during the time of the research. After making assertions based on our theme identification, we searched for disconfirming evidence throughout the data corpus (Erickson, 1986). We also discussed and checked portions of the analysis presented here with the Josephs (cf. Heyl, 2001).

Readers will note that we have used data representing both Brenda and Stella's recollections and accounts of past, and at the time, current events, in addition to the meanings that they associated with those events. Some may argue that these are post-hoc accounts and therefore, invalid. We respectfully disagree. As Wilson and Kittleson (2013) state in relation to their use of

participant narratives, the focus on participant-relayed details about their own experiences is helpful to “. . .gain insight into the dynamic between the narratives. . .used to explain their experiences (agency), narratives used to position them in their context (structure), and the consequences of these cultural narratives for the participants’ interpretation of their own persistence within science” (pp. 808–809). Because we are operating within an ethnographic paradigm, the meaning and recollections of the people actually experiencing various events and experiences are critically important. We care deeply about people’s emic perspectives relative to their lived histories because these perspectives help surface the meanings that the participants themselves make of their lives. As Lim and Calabrese Barton (2010) note relative to youths’ constructions of place, the concept of “insideness” is important. “Children critically read into their place and create layered significance and meanings of a place with critical awareness and assessment” (p. 336). We attended to Brenda and Stella’s recollections of, and meanings associated with, various situated events in Brenda’s science-related cultural learning pathways in order to understand the full complexity of, and nuances associated with, these pathways.

Findings and Discussion

In this section, we first outline high-level findings from our analysis. After that, we unfold the details of this case, starting with Brenda’s comments in an exit-interview about her science-related ideas and her interests in the sciences. We then unpack the details of the case so that readers have a sense of how we understood and interpreted the comments Brenda made during this exit interview. We start with an analysis of a leading situated event in Brenda’s life at the beginning of her participation in the study, The Perfumery, and we use this event to explicate the various details of this case as mapped to the Cultural Learning Pathways Framework. We then briefly describe other situated events in Brenda’s science-related learning pathways as we came to learn about them over the course of the study. Lastly, we attend to the details of Brenda’s school science experiences in 4th and 5th grade in order to make a case for how those experiences supported Brenda’s developing science-related learning pathways. However, many of Brenda’s school science experiences also represented missed opportunities to create linkages to out-of-school practices, which might have deepened and furthered Brenda’s interests and expertise development. We remind readers that this is a science-related learning analysis, and we were interested in investigating how everyday moments, experienced across settings, pursuits, social groups, and time, may result in scientific learning, expertise development, and identification.

An evolving and connected assembly of science-related sociomaterial practices were a consistent feature in the Joseph household during the duration of the family’s participation in the research—and extending back into Brenda’s early childhood. We learned that these practices were mainly situated in various contexts associated with “informal” learning environments (e.g., home, museums, neighborhood), and that these practices were part of a series of linked situated events that in several cases had been in existence since Brenda was a toddler. Consistent with sociocultural historical theory (Vygotsky, 1978), these practices were social, undergirded by cultural practices, and infused with Brenda and Stella’s specific lived histories. We learned that Stella identified, created, enabled, and facilitated many of these practice arrangements for Brenda, although she positioned herself as a collaborator, and at times, as a bystander. Brenda’s relationships with her cousin, aunt, and grandmother were also important with respect to Brenda’s interest development in relation to these science-related practices. Through her actions, talk, choice of activity, etc., Brenda herself identified as someone interested in aspects of the sciences, and Stella actively positioned Brenda (through her actions, talk, choice of activity, choice of settings) as someone capable of doing science-related work. In addition, we learned that Brenda

did at times utilize ideas and practices learned in school science in other contexts (e.g., during vacation, as part of a dog training class), but that for the most part, Brenda's rich sociomaterial practices related to scientific practices were largely not cued in school—except when she was given personal choice in relation to a series of science investigations.

Figure 2 is a time line representing the events and associated details that we learned were part of Brenda's science-related cultural learning pathways during the time of her participation in the research.

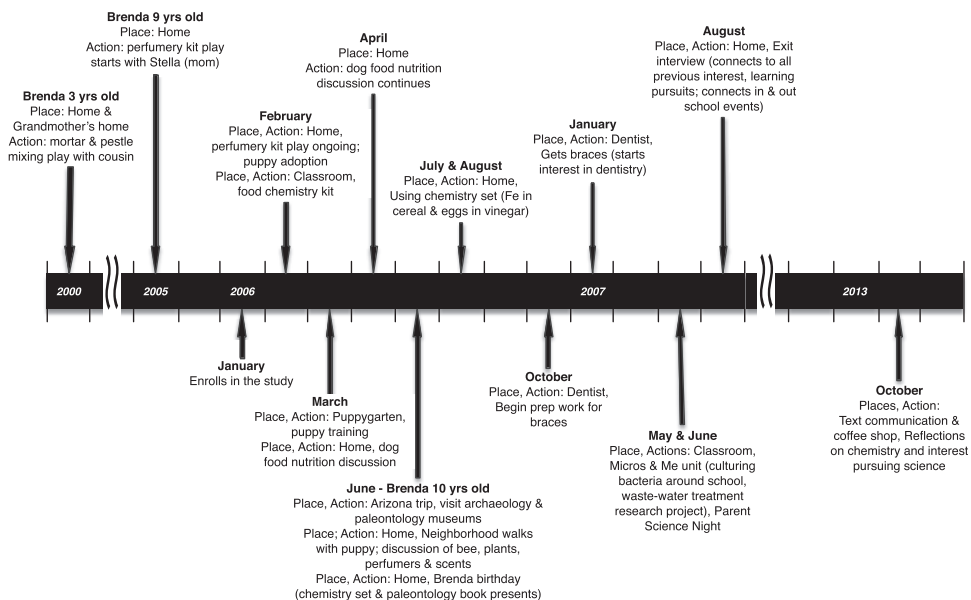


Figure 2. Situated events in Brenda's science-related learning pathways.

As we previously noted, after each visit with the Josephs we entered the details of the visit into a database that contained an account of our fieldwork. After an analysis of the database, we determined based on frequency of appearance in the database that the following types of events seemed central to Brenda's science-related cultural learning pathways:

- Events that were related to "mixing"* (the Perfumery, growing crystals, using a chemistry set to perform investigations, researching ingredients in dog food, cooking);
- Events that were related to animal behavior* (researching dog breeds and dog care, Puppygarten, researching ingredients in dog food);
- Events that were related to medicine* (Stella's profession, dental visits and home care related to getting braces);
- Events that were related to interests in paleontology* (visiting a local science museum to see a dinosaur exhibit, visiting sites on vacation, reading books), and
- Events that were related to activities in school science* (science kits exploring the chemistry of food and the interaction among land and water, a research project to investigate wastewater treatment, investigations related to microorganisms).

To provide the details that undergirded our construction of these event categories, we first turn to transcript of an interview we conducted with Brenda toward the official end of data collection.

During our first few visits with participating families, and then again at the end of families' participation (for comparison purposes), we conducted an interview to get a sense of the focal youths' images of science and technology, practices associated with science and technology, and connections they drew among science, technology, and their lives. Questions about science included: (a) What does the word "science" mean to you?, (b) Do you use science in your everyday life? If so, where and how?, and (c) Who becomes a scientist and why? We begin our explication of Brenda's science-related cultural learning pathways by reporting on her responses to these and other questions when we interviewed her at the end of her participation in the study. We will explicate the details surfaced in this segment of the interview throughout the rest of the paper in order to provide readers with a temporal and spatial view of a 2-year snapshot in what we argue is a set of related and connected science learning pathways. The following transcript segment is an excerpt from the "end of study" interview.³

1. *Leah*: So, what is science to you? Like if someone asks you that question? What does that word mean to you? What kinds of stuff do you count as science?

2. *Brenda*: It's like when you learn about something. Like you, there's like something that's happened in the past or present, like evolution or something, and you want to figure it out and stuff. And so like you have to retrace your steps and like, and investigate it and stuff.

...

3. *Leah*: So where do you come across science in your life? Different places? What would you say?

4. *Brenda*: Um, like the kitchen. And at home. Well, you know, when you cook [and] test, and definitely with your dog, or pet, because you learn about that type of species, and what they need and why things are poisonous to them and stuff. . . Outside definitely. The pollen and the plants, and bodies of water.

5. *Leah*: What about school? I mean, do you count the stuff that you do. . .

6. *Brenda*: //Bathroom definitely. The kitchen at school. And you know, classrooms. Like your desks and stuff.

In this interview, Brenda mentioned science-related topics that interested her (e.g., evolution), but the majority of her talk revolved around *doing* science. In turn of talk 2, Brenda talked about activities, such as figuring things out, retracing one's steps, and investigating as being related to science. She also mentioned cooking and pet care in turn of talk 4. Brenda discussed places where she came across science (home, outside, and in school bathrooms, kitchens, and classrooms). We knew from observing Brenda during the year and a half prior to this interview that she was referring to her engagement with various science kits at home, and her activity related to taking care of the family dog. She and Stella went on long walks in the neighborhood and spent time looking at various trees, smelling flowers, and gardening. As for school, Brenda was referencing a unit about microbiology and human health during which she cultured bacteria collected from her classroom, and school bathroom and kitchen.

As the interview progressed, Brenda went on to describe seeing fault lines when on vacation in California, and seeing formations that represented "deltas" on sidewalks while on walks with her friends in the rain (her mention of deltas was directly related to a land and water unit she participated in during 5th grade). When asked about other science-related activities in which she participated at the time, Brenda noted gardening with her cousin, cooking with her mother and grandmother, going to museums on vacation, participating in sports (e.g., swimming and soccer at the time), reading food labels in order to make nutritional decisions, and getting braces. Brenda

also noted that she thought that “science” would continue to be of interest to her. Additionally, and as part of this same interview, we asked the following question:

7. *Leah*: So what about your chemistry? Are you still interested in chemistry? Mixing and. . .

8. *Brenda*: //yes, but not as much. . . Well, I guess mostly medicine. I really think mixing medicines is interesting.

...

9. *Leah*: . . . I have a question for you. Remember. . . because this was exactly the question we were on the very first time [i.e., the first interview after Brenda enrolled in the study]. . . and you were like, The Perfumery! And you got up and ran and got your Perfumery, you know? . . . But, did you count that as science? Like was that science to you? . . . The Perfumery?

10. *Brenda*: //Mm-hmm. Yes. I, I mainly like mixing the liquid with, liquids with powder, which is like cooking is so awesome when you like make cakes. Cause like you mix the eggs with the flour, and the sugar.

Science as Coordinated Sociomaterial Practice

During our third home visit with the Josephs, and when we asked Brenda, “What comes to mind when you think of science and. . . learning science?” she responded immediately: “chemistry.” Once Brenda responded, we remembered a conversation we had with the Josephs when they first enrolled in the study about a “kit” that they had just purchased. We mentioned this memory, and Brenda said, “Oh yeah! The Perfumery. Let me go show it. . . It’s so much fun.”

Brenda went into her bedroom to get the Perfumery, a purchasable science activity kit that was readily available at the time at the gift shop at a local science center, and online. The kit contained everything one needed to make perfumes (e.g., different oils, such as peppermint oil, bottles in which to mix the perfumes, plastic pipettes, instructions). A tag line on the box said, “It’s real chemistry!” Brenda began to demonstrate the Perfumery and she started by showing us how she had organized the Perfumery materials. All materials were stored in a large Ziploc bag. Each plastic pipette was labeled and rolled in a paper towel. Brenda noted that she had labeled the pipettes (they did not come labeled). Each bottle of perfume oil was stored in a smaller Ziploc bag within the larger bag. In other words, all materials were organized, labeled, and stored in ways that made it easy to identify and access them.

For the rest of that home visit, Brenda used the Perfumery while Stella commented and we watched. The following transcript segment captures the activity and the conversation:

1. *Brenda*: I’m going to put a couple more drops of apple. Oh that’s way too much. ((Using the dropper, Brenda transfers the drops she took from the scent bottle and places them in a small, white, plastic vial.))

2. *Brenda*: There. ((Again, using the dropper, Brenda squeezes out any remaining liquid into the original scent bottle. She then squeezes the dropper three times and wipes the top of it on the paper towel and then places the dropper back with the other droppers.))

3. *Brenda*: And then. . . close this up. ((Brenda takes the top of the scent bottle and screws it back on the bottle. She places the bottle back with the other scent bottles. Note that the scent bottles are all placed neatly in a row. All of the droppers to her right are also placed neatly in a row.))

4. *Brenda*: I would eat some jasmine, it smells so good. ((Brenda picks up another scent bottle and unscrews the top.))

...

5. *Brenda*: I'll do. . .seven of this.

6. *Stella*: And um, in her journal. . .actually.

7. *Brenda*: //I've been writing down all the potions that I'm making. ((Brenda places the dropper she picked up into the scent bottle that she just opened. She squeezes the bulb of the dropper, draws the dropper out of the scent bottle, and looks at how much liquid she has in the dropper.))

We purchased a Perfumery kit so that we could better understand what was included. Besides the perfume oil, the kit contains the plastic droppers that we saw Brenda use, and an instruction booklet. Brenda and Stella purchased or otherwise obtained the various vials in which Brenda mixed the different perfume oils. As Brenda noted in the transcript, she created the various labels that we saw on the vials, and on the droppers. The instructional booklet contains different perfume-mixing activities that a kit user can try (e.g., "Test Your Fragrance Memory," and "The Taste of Smells"). The booklet also contains metadiscourse (Lemke, 1990) linking the various activities one can do with the Perfumery to the study of chemistry. The following text is an example:

The art of perfume would not exist without chemistry. Everything in our universe is made of tiny particles called atoms. Atoms are so small we can't see them through a normal microscope. Atoms join together to form groups called molecules. Water is one example of a molecule. It's made of two hydrogen atoms and one oxygen atom. Chemistry is all about mixing molecules to create entirely new substances. Although you can't see it, chemistry is at work in your garden as plants change molecules of carbon dioxide into the oxygen we breathe. In laboratories, chemists make useful new substances by mixing stuff together. In perfume laboratories, chemists experiment with aromatic oils from flowers, leaves, and other ingredients to make perfumes and study how scents affect us. (GiddyUp, 2011, p. 11)

As we watched Brenda work with the Perfumery at home on her dining room table, we noted her use of many practices that are highly valued in scientific research (cf. Sismondo, 2010). These included: (a) control for contamination with apparatus, (b) careful measurement of materials during implementation of protocols, (c) tracking and labeling of samples, and (d) systematic journaling of results. As illustrated by the transcript, Brenda was using various pieces of equipment (e.g., droppers, vials). As Harré (2010) notes, "Equipment is the meeting point between the active experimenter and the potent stuff of the universe" (p. 30). In addition, Sismondo (2010) discusses the amount of tinkering that takes place during laboratory research, and Brenda and Stella were certainly tinkering with respect to mixing the various perfume oils in order to obtain the scents they liked. During her activity, we noted Brenda talking directly to various labels on the plastic pipettes that appeared to be falling off, saying statements such as, "Oh, the tape is coming off. No, no, no. Don't come off, tape. Please don't. Please don't do this to me." Talking with aspects of one's phenomenon of interest, even if those aspects are inanimate objects, is a documented feature of professional scientific practice that serves an epistemic purpose (Ochs, Gonzales, & Jacoby, 1996). These same practices involving equipment that Brenda was using are certainly highly valued in school science as well, as evidenced by newly focused attention on the importance of engaging students with scientific practices (NRC, 2012).

While perfuming in front of us and describing other Perfumery sessions, Brenda and Stella talked about using trial and error and iteration, known practices in science and engineering research and design (cf. Crismond & Adams, 2012), to learn more about the characteristics of the various perfume oils they used and how those characteristics interacted once the oils were mixed together. Brenda and Stella's activity within the Perfumery constellation of situated events was always highly collaborative. They worked side-by-side and used supportive gestures, such as touching each other's arms. In addition, they used the pronoun "we" to describe their Perfumery-related practice. Each contributed to the perfume making and had roles to play. Brenda performed the "doing" of the Perfumery, while Stella played the role of supportive assistant (e.g., provided suggestions, guidance) (cf. Henze, 1992). Derksen (2010) describes people as scientific instruments in the social sciences, noting that scientific instruments can be divided into "...those that produce phenomena, and those that register them..." (p. 22). Stella's commentary (and continuous question-asking) relative to Brenda's activity served to guide Brenda, and prompt her thinking.

We also noted Brenda taking various stances with respect to this activity. As quoted, Brenda described this activity as "fun," and she noted that she had choice as to what types of perfumes to make ("I'm making up my own."). Brenda positioned herself as a competent perfume maker by systematically enacting the aforementioned practices. Stella also positioned Brenda as a competent perfume maker by saying, "...you actually did come up with some very interesting...ones." Note the role of affect in learning. It was clear to us at the time that Brenda was very excited about the Perfumery and loved working with it (e.g., running to her bedroom to get the Perfumery, wanting to demonstrate her perfuming for us, noting several times—with feeling—that the Perfumery was "fun!"). As Lemke (2010) notes, "...we learn by feeling... it may well...serve to help bridge across experiences in different places, times, and activities, as we seek, in the moment or retrospectively, to make meaning along the trajectories of our lives, including our lives as scientific actors..." (pp. 2–3, italics in the original). In addition to acting scientifically while making perfumes, we contend that Brenda was also *feeling like a scientist*. This "feeling" functioned as the bridge Lemke describes in the aforementioned quotation; the bridge connecting the various situated events that Brenda counted as mixing- and chemistry-related.

It is questionable as to whether Brenda learned details about atoms, molecules, and chemical reactions to which the text in the Perfumery instruction booklet refers. In fact, we would hypothesize that she did not learn about what is traditionally thought of as chemistry content through her Perfumery activity at the point in time captured in the transcript. The scientific content was not the focus of Brenda and Stella's Perfumery-related discourse, however. Brenda and Stella were focused instead on the practices involved in making perfumes, as well as the uses of the perfumes in their lives (e.g., gifting perfumes to friends and relatives, spraying perfume into the air in their home). We argue that the material practices and the learning involved in their coordination and implementation are important outcomes in their own right with respect to STEM-related learning. Additionally, and related to science learning in everyday contexts, it is not clear that the leading learning-criterion should always be a tethering of activity to core ideas (i.e., content). Many hobbyists report that they first became interested in the "doing" of their hobby, and then went on to understand that what they were doing was directly related to core ideas in formal science (or other disciplinary arenas) (e.g., Azevedo, 2013). With respect to Brenda's stated interests in chemistry, and seeing her Perfumery practices in action, we wanted to learn more about how Brenda became so engaged with activities and practices she coded as "mixing," and related to science (chemistry in this specific instance).

Recollections of Influences on Brenda's Interest in "Mixing"

Brenda mentioned several times over the course of her enrollment in our research that her aunt was a chemist. Brenda mentioned her aunt's work when Brenda talked about her interest in chemistry, and as a way to position herself to others as the kind of person who had participated in certain types of scientific work. For example, when Brenda was in fifth grade, we co-designed a personally consequential microbiology curriculum unit in collaboration with fifth grade teachers at Granite Elementary School (Tzou et al., 2007). During a focus group in which Brenda and some of her fellow students participated, we asked what aspects of the unit they had participated in before—in another context. Brenda shared that she already knew how to make agar (during the unit, students cultured microorganisms from samples taken from around their school—for example, on computer keyboards, in the bathrooms, on plants in the school's outdoor garden). When we asked Brenda how she knew how to make agar, she said, "My aunt [the] chemist." One of her fellow students asked if her aunt was a chemistry teacher. Brenda said that no, she was a chemist who worked in a lab. Brenda said, "She [Brenda's aunt] used to be a chemist. She was a chemist. But like she, like. . . she made like a whole bunch of stuff. . . she like, did medicine related stuff and. . . DNA."

At the time of her enrollment in our study, Brenda was an avid Harry Potter fan and had read all of the books. She often talked about "potion making" with respect to her love of mixing and chemistry. In addition to the fact that Brenda's aunt was a chemist, we asked Stella if perhaps Brenda's love of mixing and chemistry also stemmed from her interest in Harry Potter. The follow transcript segment explicates Stella's response to our question:

1. *Stella*: . . . You know, I remember seeing that [The Perfumery] at the store and she likes potion making and actually she's been doing it, you know, she and her cousin [name of cousin], they go into my mother's bathroom and my mother likes a lot of cheap perfumes.

...

2. *Stella*: So, you know, they go in, they lock the door. . . you know, because they know, they don't want us to come in. And then you know, we hear them and they are pounding stuff. ((Stella pounds her right fist into her left palm.))

...

3. *Stella*: ((laughs)) and they are mixing stuff and we're like ((makes a gesture with her right fist as if she is knocking on a door)) what's going on in there? They won't let us in yet and of course, when we come in, it's, it's a wreck in there and it smells really (inaudible).

4. *Stella*: ((picks up the perfumery contents in the large Ziploc bag)) and I thought, ok, you know? . . . Natural scents. ((laughs)) As far as we can see, it's, you know she's not going to make anything harmful. . . But she really took to that very quickly. . . She just fell in love with it when she saw it. (inaudible)

5. *Researcher 2*: So where did the potion making come from? Do you have a sense? Is it from the books like the, the magic books, or is it just from time with [name of cousin]?

6. *Stella*: //No. Actually, both she and [name of cousin] just have liked that from toddler-hood. . . You know? Um. it's and the favorite thing that they have is you know, every Haitian kitchen. . .

...

7. *Stella*: //has to have one of these. You know it's a mortar and pestle. ((Stella brings a large, wooden mortar and pestle into the dining room. She taps the pestle twice rapidly into the mortar.))

8. *Leah*: //It's a mortar and pestle.

9. *Stella*: Yeah. . .you know it everything that we start out with. . .always if it's savory cooking, it's um garlic ((Stella taps the pestle on the rim of the mortar)) and scallions and ((she puts the pestle in the mortar)) and pound with salt and pepper. . .So you know my mother has I mean, I only have one, you know, I'm a slouch! ((As she is saying this, Stella takes the pestle, with her right hand, out of the mortar)). . .My mother has probably has like four or five ((Stella taps the bottom of the mortar with the pestle rapidly three or four times)) at her home. You know? And they [Brenda and her cousin] watched her actually cooking and you know, it's, it's they would be running away with one of those and they would put rice and all sorts of things in there ((Stella puts the pestle in the mortar and taps rapidly about five times)) and they would go and they'd say, "Here mom, look what we made!". . .Um. But from that time on ((Stella turns back toward the kitchen to put the mortar and pestle away)). . .

....

10. *Stella*: // . .they have, they have really like to kind of make different things. . .Um, and we felt that you know if it's things like food, and of course it's, we didn't let them have access to the perfumes until later. . .But if it's with food, it's fine, it's safe. You know. It's, it's we're not going to let them have access to anything that could be harmful to them.

In turn of talk 1 of this transcript segment, Stella linked Brenda's interest in The Perfumery with Brenda's long-held practice of "potion making" or "mixing." Brenda's collaborator in this venture was a cousin. Stella described that the two children would lock themselves in a bathroom and would mix their grandmother's (Stella's mother's) perfumes. Starting in turn of talk 6, Stella countered the assertion that this love of mixing stemmed from books (e.g., Harry Potter). She described instead that it was fostered by the use of mortars and pestles in Haitian cooking. Readers will also notice an emphasis on safety (turns of talk 4 and 10), which was a prominent feature of Brenda and Stella's joint sociomaterial practices in the "mixing" related learning pathway, and in the other learning pathways as well. Obviously, attention to safety when performing various scientific practices is critical in professional science, and school science, laboratories (see NRC, 2006). We contend that the various sociomaterial practices embedded in this "mixing" learning pathway, and the coordinated participation with close collaborators, helped create scopes of possibilities related to Brenda authoring a scientific identity. These practices and events enabled Brenda to "try on" various identities associated with her interests, and develop passionate feelings related to those interests, which as noted earlier might have served to bind together the various constellations of situated events along Brenda's science-related cultural learning pathways.

Stella's Orchestration of Brenda's Science-Related Learning Pathways

We have utilized the Perfumery as a heuristic that allowed us to delve deeply into aspects Brenda's interests in mixing, and her involvement in associated sociomaterial practices. These practices were: (a) jointly constructed through participation with trusted collaborators (e.g., Stella, her cousin, her aunt), (b) temporally lengthy (meaning that all of the associated events and collaborations were long-term and on-going), and (c) involving tools and artifacts that Brenda manipulated in particular ways for particular purposes. We also sought to show that various Perfumery-related events (e.g., mixing with her cousin starting at age three, time spent with her aunt who is a chemist, the Perfumery kit) were linked through the actors involved (i.e., the importance of Brenda's social relationships), the sociomaterial practices in play, and the material

arrangements present, which provided Brenda with opportunities to continue exploring her interests, identify with various aspects of activities embedded in these events that she related to science, and be positioned as someone who was capable of this type of coordinated activity.

Readers might note in our descriptions of Stella's activity during the Perfumery episodes (and in relation to other events and practices that we describe later in the paper) that Stella appeared as another participant in the setting, a collaborator, and at times, a bystander. In fact, Stella told us that she actively positioned herself as such because she was genuinely interested in participating in these various events and practices (or at times allowing Brenda to be the sole participant), but also wanted access to Brenda's thinking ("I just love the way she thinks!"). More than a co-participant of course, Stella actively orchestrated most of the details related to the situated events in Brenda's learning pathways. For example, by allowing and fully supporting the potion making activity when Brenda and her cousin were younger, and then by purchasing a science-related kit that was directly related to the potion-making interest, Stella both coordinated various details of the situated events in which Brenda participated, and positioned Brenda as a person who was competent with respect to the skills required to participate in these events. In addition, and by her aforementioned actions, Stella positioned activities like The Perfumery and the earlier potion-making exploration as worthwhile activities, activities that helped contribute to Brenda's deepening interests in science (and at this moment in time, chemistry specifically).

As Brickhouse (2010) notes, "To have a scientific identity one must perform in ways that are recognizably scientific to others" (p. 57). She continues, "As one performs and is recognized as being scientific, the actual competence becomes internalized in a way that it becomes part of who you are." Returning to social practice theory, Holland and Lave (2009) discuss the Vygotskian concept of semiotic mediation where symbol systems are first engaged through social interactions, before being internalized (see Vygotsky, 1978). Was Stella orchestrating the details of various events in Brenda's science-related learning pathways so that Brenda would position herself as scientific and capable of doing science, and thus come to identify (in part) as a person interested in science?

In a study of parental support related to the development of young people's technological fluencies, Barron, Martin, Takeuchi, and Fithian (2009) found that parents played a variety of roles in order to ensure their children's continued learning, interest development, and participation.

Most of these roles did not require the parent to have greater technical expertise than the child. Parents could collaborate with them, learn from them, broker outside learning opportunities for them, provide nontechnical support for them, or employ them, and these types of engagement furthered learning. Parents also played instrumental roles when they shared their technical expertise through informal teaching processes or provided their children with learning resources such as books or new media tools. (p. 5)

We certainly saw Stella performing these various roles with and for Brenda. We also saw her engage in various pedagogical practices as part of her collaborations with Brenda. For example, she utilized specific questioning techniques to make Brenda's thinking visible (e.g., Chin, 2007). Although beyond the scope of this analysis, Stella's mother was a teacher, and we have often wondered whether Stella learned to implement the pedagogical practices she utilized during her collaborations with Brenda (and as part of orchestrating Brenda's activities) from her own mother.

Other Situated Events in Brenda's Science-Related Cultural Learning Pathways

In Figure 2, we represented that we observed Brenda and Stella using other science-related kits that involved "mixing." For example, we gave Brenda a chemistry set for her birthday during

the first year she was enrolled in the study (and did so because of our observations of the Perfumery, and her stated interest in chemistry at the time). In addition, Brenda selected a crystal making kit to explore as part of a science kit interview protocol we developed.⁴ By providing these kits, we provided new situated events (and possibly new collaborators—us) that fed into the “mixing” cultural learning pathway. Both of these kits provided opportunities for Brenda and Stella to utilize many of the same sociomaterial practices that we saw them utilize during the Perfumery (e.g., use of equipment, joint participation, measurement, following protocols, tinkering). With respect to the chemistry set, we observed Brenda and Stella working on two different investigations. One was an investigation that helped Brenda and Stella explore whether iron was present in the various cereals they ate. The other investigation involved placing eggs in vinegar and observing the outcome over time. With respect to the crystal making kit, Brenda and Stella made crystals in their kitchen, and then observed them grow. From listening to Stella’s account of Brenda’s early mixing activity with her cousin involving a mortar and pestle, the crystal making activity appeared to have some of that same texture—attending to science safety, using kitchen apparatus and tools to participate in activity that the participants themselves counted as related to science, and working with trusted collaborators.

Aspects of Brenda’s school science experiences (at the time of her enrollment in the study) also fed into our analysis of Brenda’s science-related learning pathways and we will turn to those experiences momentarily. Before doing so however, we want to provide a sense of some of the other events mentioned in Figure 2 (i.e., events related to animal behavior, events related to medicine, and events related to an interest in paleontology). As Brenda alluded to in her “end of study” interview, one focal event during the family’s participation in the study was the acquisition of a dog. Brenda and Stella brought their new dog home in February of 2006. During our initial home visits, we noticed many different dog-related books (e.g., how to care for dogs, which breeds to choose given allergies). Brenda and Stella talked about the research they had been doing in preparation for getting the dog (e.g., talking with trusted others, reading various books). After the dog arrived, Brenda and Stella enrolled her in dog training school (called Puppygarten), where the dog trainers not only helped owners train their dogs (e.g., to sit, to heel), but also provided advice about care. Much of this advice was related to dog health-care. We accompanied Brenda and Stella to Puppygarten twice and documented the topics trainers discussed. For example, the trainers talked about why chocolate can kill dogs. They talked about the fact that some dogs are allergic to bee stings and can die if stung. The trainers talked about dog nutrition and taught participants what types of ingredients to look for on dog food labels. During a subsequent home visit, we participated in dog food label reading. Brenda and Stella were comparing and contrasting the labels on dog food brands in order to look for which brands contained natural ingredients and which brands contained “filler,” a low-cost ingredient that does not contain much, if any, nutritional value (something discussed by the trainers at Puppygarten). As Brenda noted in the “end of study” interview, by taking care of her dog, she learned, “. . . about that type of species, and what they need and why things are poisonous to them. . .”

Also documented in Figure 2, Brenda mentioned early in her participation in the study that she was interested in paleontology. Stella asked us before the two took a trip to Arizona if we knew of any museums and/or programs in Arizona that they might visit and/or participate in during their trip. When we accompanied Brenda and Stella to a local science center, we spent the majority of the visit time in a special dinosaur exhibit, and Brenda and Stella engaged in various debates about how the fossils that were part of the exhibit were constructed. Perhaps Brenda’s interest in evolutionary biology that she discussed during the “end of study” interview was related to her earlier interests in paleontology.

Finally, with respect to the situated events related to medicine, Stella works in the health care industry, and discourse about health and health care was a constant feature in the Joseph's home during their enrollment in the study. Additionally, and as Brenda noted in conversations with her classmates about her aunt's job, her aunt was a chemist and did "...medicine related stuff." Through Puppygarten, Brenda and Stella learned about foods and organisms that might be harmful to their dog, and they learned about what types of foods were most nutritious. Toward the end of Brenda and Stella's first year of participation in the study, Brenda got braces put on her teeth. Over the course of her visits to the dentist, she developed an interest in dentistry and told us that she wanted to become an orthodontist. She told us that her dentist offered to host her for an internship when she was older. As Brenda noted in her "end of study" interview, her love of mixing had now navigated toward the context of medicine, "I really think mixing medicines is interesting." She went on to say that she enjoyed mixing cough medicines, but was quick to also note that she did not drink what she mixed because that would be dangerous.

We have attempted to highlight the various situated events that were tied to Brenda's developed and developing interests in various domains (e.g., mixing, taking care of pets, dentistry), and we contend that these events were part of Brenda's science-related cultural learning pathways at the time of her enrollment in the study. Returning to Figure 1, we outlined (through the use of narrative accounts and Figure 2) that these events took place in a variety of settings and over a span of years. We highlighted the types of sociomaterial practices that were part of these various events (using the Perfumery as an example), and contend that the details of the sociomaterial practices within situated events were similar across events and contexts (e.g., deep social relationships with family member collaborators, the same type of close coordinated participation structures). Our claim is not that Brenda was already expert at employing these practices, but we do argue that through these various activities, which provided opportunities for Brenda to participate in these sociomaterial practices, she was beginning to develop professional vision and competency (see Goodwin, 1994). The temporal dimensions of these practices and events were also similar in that time was similarly textured (e.g., sustained time and focus on task). We portrayed the coordinated participation during these practices between Stella and Brenda, and noted that Stella positioned Brenda as the kind of person who was capable of participating in these events. We argue that all of this taken together created a scope of possibility that Brenda would develop science-related expertise, which could open opportunities to possibly pursue a science-related career and/or continued interests.

Situated Events in School Science

Brenda's participation in school science was a prominent situated event in her science-related cultural learning pathways. Brenda was at the time of her enrollment in the study, and has remained, a very good student (as evidenced by her grades, for example). Brenda's elementary school utilized kit-based instruction as the foundation of their science education programming. As we note in our accounting of a portion of Brenda's "end of study" interview, Brenda utilized many of the concepts she learned about in school during her everyday activities. For example, in 4th grade, she participated in a food chemistry kit, and one of the activities in the unit involved learning to read nutrition labels on various foods. As noted in Figure 2, Brenda's participation in the food chemistry kit was taking place during the time when Brenda and Stella acquired a dog, and when they took the dog to Puppygarten (where Brenda also learned about how to interpret food labels and the importance of doing so for dogs' nutrition). One could argue that Brenda's school activity helped her identify with the Puppygarten-inspired activity that then led to Brenda and Stella comparing dog food nutrition labels at home.

Brenda also participated in an ecosystems kit during 4th grade, where she and her classmates built miniature ecosystems in two-liter bottles. They planted seeds in their bottles and placed crickets and isopods in them. As part of the kit activity, Brenda and her classmates poisoned their ecosystems to study the effects of pollution on the environment. Readers will recall that Brenda discussed pollen, plants, and bodies of water during the “end of study” interview, topics that she identified as related to science. In addition, she noted that she gardened with her cousin. We often accompanied Brenda and Stella on walks around their neighborhood, where they would stop to smell flowers, touch leaves, etc. In 5th grade, Brenda participated in a kit that featured connections among land formations and water, so that students could learn about erosion, deposition, etc. Brenda talked about deltas during her “end of study” interview, noting that she and her friends noticed formations that looked like deltas on the sidewalk after it rained. Brenda also said that she noticed fault lines while traveling with family in California. These were all topics of discussion during the kit-based activity in 4th and 5th grade. We were convinced that Brenda was utilizing aspects of what she was learning in school during her participation in other situated events at home (and in other contexts like museums), and that she was looking for examples “out in the world” of what she was learning about at school.

However, the school science situated event was not always coordinated with the other situated events in Brenda’s science-related learning pathways, and thus, we contend that it could have constrained Brenda’s scopes of possibilities related to efforts to continue to pursue and deepen her interests and science-related identities. For example, during one activity in the food chemistry kit, we observed Brenda and her classmates use plastic pipettes to place several drops of various liquids (water, cornstarch, corn syrup, corn oil, milk) onto paper-bag squares, and then observe the behavior of the liquids in order to determine which of the liquids contained fats. The title of the activity was, “Testing Liquids for Fat.” Students were asked to make a data table with the liquids they were testing listed in the first column of the table. They were then asked to predict what they might observe relative to each liquid’s behavior on a paper-bag square (second column of the table), record their actual observations (third column of the table), and then make a determination based on their observations as to whether each of the liquids contained fats (fourth column of the table).

We noted that some of Brenda’s sociomaterial practices during the Perfumery (again, our observations of these events were taking place during the same time period) reminded us of her activity in school science. As a reminder, Brenda labeled all of the plastic pipettes (or “droppers”) that she used during the Perfumery activity. During school science, Brenda seemed intent on keeping her materials organized. In addition, Brenda tended to spend the majority of her time during science activities readying her materials and constructing recording aides, such as data tables (e.g., Brenda would use her ruler to make tables versus simply sketching them in her notebook), charts, graphs, etc. Many sentences in our field notes related to observations of Brenda during school science begin like this: “After Brenda arranges her tools. . .,” and “Brenda seems to spend a lot of time on set-up. . .” (Field note excerpt on Feb. 7, 2006).

We concluded that Brenda, during this time period, certainly appreciated keeping her materials organized and accessible. We were uncertain at the time however if she coded these practices as “scientific” and identified them as practices that scientists “do,” and thus, made sure to also engage in these practices. We came to reject this assertion over time because of the specific details of what was on the surface very similar work in both contexts (i.e., sociomaterial practice using some of the same tools [plastic pipettes], and identified in both contexts as chemistry-related). When looking more closely at the data, we noticed large differences between the two activity systems (Perfumery and liquid testing in school science). Although Brenda’s physical arrangements of various materials seemed similar between the Perfumery activity and Brenda’s

school science activity, the details of the work were vastly different. First, Brenda spent an inordinate amount of time on task with respect to the Perfumery. Stella told us that she and Brenda had been working with the Perfumery for approximately 6 months prior to showing it to us, and that they participated in Perfumery activity almost every weekend during that time period. The school science activity had a very different temporal quality to it. Although Brenda and her classmates usually spent time each day participating in school science activities, very few activities took longer than 15 minutes to complete. Thus, the *texture* of time in these two contexts (home and school) and relative to these two activities (the Perfumery and fat testing) was very different.⁵ The food chemistry activity in school science did not appear to cue Brenda's various sociomaterial practices that we saw her enact with Stella during the Perfumery (and other science kits she used at home).

Brenda rarely talked in whole group discussions in schools, but was quite talkative in out-of-school contexts. Additionally, the identities that Brenda adopted during school science were that of "student" and sometimes "collaborator" when the activity was such that she was expected to work with peers. However, these collaborations were of a different kind than Brenda's collaborations with Stella with respect to the Perfumery and other activity at home. Unlike the discourse during the Perfumery, Brenda and her food chemistry collaborators' discourse only peripherally related (if it related at all) to the food chemistry task at hand (whereas all of Brenda and Stella's discourse during the Perfumery activity related to that specific activity). In the field notes that we took during the food chemistry activity, we noted that Brenda and her collaborators talked about topics including: pet names, getting shots at the doctor's office, and chipping and losing teeth. The only discourse related to the food chemistry activity itself was about who would set up the materials and who would clean them up.

Cuing Aspects of Brenda's Sociomaterial Practices in School Science

As we noted earlier in the paper, we worked collaboratively with Brenda's teacher and the other 5th grade teachers in the school to design and implement a personally consequential microbiology unit. Students investigated various microorganisms and their connections to the students' lives (e.g., food production, health, and fellow inhabitants in classrooms, school bathrooms, and the like). As noted, one of the activities was to culture microorganisms. After swabbing various surfaces in their classroom, their school, and outside (e.g., swabbing a leaf in the school garden), students plated petri dishes, taped the dishes shut, and labeled them. The dishes were kept on a counter top while colonies of microorganisms grew. During this time period, the school hosted a parents' night so that parents and other adults the students invited could come and see the work that students were doing in school. Brenda hurried Stella over to the petri dishes and started to explain how she and her fellow students had cultured microorganisms and what types of microorganisms were growing on the plates. She talked enthusiastically about the investigation and how much she enjoyed it. Her teacher remarked to us how unusual it was to see Brenda so engaged. However, we did not consider it unusual at all because this was the identical affect, and interaction dynamics between Brenda and Stella, that we were used to seeing regularly as part of other situated events outside of school.

In addition to the various microorganism-related investigations that students conducted, they also participated in a research project to explore various topics of their choosing related to microorganisms and their interests. Brenda chose to learn more about wastewater treatment, the various processes involved and how ultimately, the water is purified. She noted that she had first become interested in this topic during a school-sponsored trip to an environmental-themed camp. As Brenda worked on her project, she told us that she was fascinated by the topic. Stella noted to us that Brenda worked for hours on the project at home, and really seemed to enjoy it. Brenda's

teacher also noted the time and effort that Brenda put into the project, but assumed that Brenda getting too much help at home or that someone had done the project for her (Field Note on June 12, 2007). We understood that this erroneous assertion stemmed from the fact that Brenda's teacher had little to no idea about Brenda's situated events and sociomaterial practices outside of school.⁶

When we asked students to reflect on their experiences during this personally consequential microbiology unit, Brenda noted that the unit was one of her favorites. We contend that the aspects of the unit (e.g., culturing microorganisms, performing investigations with yeast, working on a research project of her choice) created sociomaterial arrangements that Brenda coded as being familiar (e.g., carrying the same interest-factor as the situated events in which she participated in outside of school, involving similar sociomaterial practices). Returning to Gonsalves et al. (2013) three-part model of identity (competence, performance, and recognition), we contend that while other school science experiences may have enabled Brenda to appear competent (e.g., she accomplished her school work as directed, she earned good grades), she was not always able to perform in ways that she was used to performing in the various out-of-school contexts related to her developing science learning pathways. In other words, much of her school science activity did not provide opportunity for Brenda to participate in complex and coordinated science-related sociomaterial practices with trusted collaborators. Additionally, her teachers in 4th and 5th grade did not recognize her, and therefore position her, as someone who was excited about science. Elements of the microbiology unit enabled Brenda to “. . .actively produce talk and action that support[ed] [her] recognition by others” (Zimmerman, 2012, p. 599). As Holland and Lave (2009) note, social practice theory is a “. . .historical [and] material theory. . .that integrates the study of persons, local practice, and long term historically institutionalized struggles” (p. 1). Brenda's case highlights the institutionalized struggle that Dewey outlined over a century ago (and as noted at the beginning of this paper); the oft stark disconnect between school and most other contexts in youths' lives.

We have highlighted salient cultural specifics related to forms of privilege, tension, and marginalization documented in the data. Notably, these included the multi-generational cultural practices related to the ethnic history of the family, the use of the family's financial resources to extend Brenda's learning across a set of institutional settings, and the recognition issues related to Brenda's science identity in the school setting. In this way, we have elected to document how power-related issues related to learning and becoming are documented *through* the situated events along the learning pathway (cf. Latour, 2005). These details are supported through the case study data and have been verified through member checking with the participants.

What implications do these disconnects among in- and out-of-school settings have for youths' science-related learning pathways? For some of the youth who participated in our research, the consequences of these disconnects were grave with respect to their perusal of continued education and careers connected to their interests and broader learning pathways. In Brenda's case, the disconnects have not dampened her interest in the sciences, nor have stood in her way of her school achievement. In a recent conversation with Brenda, she noted:

I probably will end up going into a science related professional because I seem to be really interested in healthcare, specifically psychology and therapy at the moment. I've also been finding myself really interested in anatomy and physiology. It is the science class that I am taking this year, so maybe something in connection with that (personal communication, October 8, 2010)

In their new book, Steele and Cohn-Vargas (2013) describe the concept of “identify safety” as a counter to various instantiations of stereotype threat (see Steele, 2010). Steele and Cohn-Vargas note that students achieve and are challenged when their experiences, interests, cultural and

language practices, etc. are made visible, acknowledged, and seen as assets in their intellectual growth. As we noted, Brenda's teachers at the time she was enrolled in the study had little to no idea that Brenda participated in such a wide variety of situated events that were science-related. However, Stella and others who Stella recruited were able to afford Brenda these opportunities so she was able to continue to pursue her interests and explore her science-related identities.

We can trace aspects of Brenda's most recent comments (e.g., an interest in health-related issues and contexts) back to elements of her science-related cultural learning pathways that we started to learn about 7 years ago. We often see calls in the literature to learn more about youths' lives and then to leverage interests, hobbies, etc. in ways that will help support youths' science learning (cf. González, Moll, & Amanti, 2005). As Gutiérrez and Rogoff (2003) note, "Individuals' background experiences, together with their interests, may prepare them for knowing how to engage in particular forms of language and literacy activities, play their part in testing formats, resolve interpersonal problems according to specific community-organized approaches, and so forth" (p. 22). We would agree that Brenda's experiences and interests at the time she was enrolled in the study certainly prepared her to engage in a practice-focused conception of science education. However as Lemke (1990) notes, school science curriculum is currently not usually curriculum "... that reflects student interests... teachers' cumulative experience and advice, or any systematic study of the life-value of its content." (p. 179). As Brenda herself noted at the time of her enrollment in the study, she wanted a curriculum that was more challenging and aligned with her various interests (by providing her some choice with respect to her learning, for example). We are hopeful that the vision outlined in *A Framework for K-12 Science Education* (NRC, 2012), especially the vision of youth engaging in scientific practices, will help guide the type of curriculum development that Lemke describes. Without attention to STEM-related aspects of youths' cultural learning pathways both in and out of school however, the disconnects between many aspects of school science and everyday learning related to science seem destined to remain firmly intact.

Concluding Remarks

Returning to the Cultural Learning Pathways framework shown in Figure 1, we have utilized the details of Brenda's case to highlight how everyday moments, experienced across settings, pursuits, social groups, and time, may result in scientific learning, expertise development, and identification. We have argued that Brenda, at the time of her participation in our research, was constructing (with the help of a myriad of others, first and foremost being her mother Stella) various science-related learning pathways over the course of Brenda's childhood. These learning pathways were socially, culturally, and historically rooted. Using the Perfumery as one example of an everyday moment, we mapped the details of that activity onto the framework. For example, we unpacked the details of the sociomaterial practices involved in the Perfumery activity, and highlighted how those practices influenced and were influenced by Brenda's science-related interests (especially related to the *doing* of science), her social relationships with others (e.g., her play with her cousin, her grandmother's cooking), and the coordinated participation they achieved as they engaged in the practices. We also showcased Brenda's developing identity as someone who could do science, and who was interested in the sciences. We attempted to make the case that these aspects of Brenda's sociomaterial practice (e.g., interest, coordinated participation, identity formation) were learning outcomes as part and parcel of her participation in these practices.

The left side of Figure 1 calls attention to the details of any given situated event (e.g., details of the place[s] where it occurs, related actions, and actors' positioning), but also to the value of examining these same details in situated events as they occur over time. For example, we showed how Brenda was positioned by Stella as the kind of person who could do science and be interested

in science during Perfumery activity, but then documented that this same positioning work took place within and across all out-of-school situated events in Brenda's science-related learning pathways. We outlined the details of Stella and Brenda's coordinated action in order to accomplish perfuming (or crystal making, or purchasing a pet), and we outlined other situated events (e.g., mixing lotions with a cousin years prior, using a mortar and pestle to mix other materials) in these science-related learning pathways. We problematized the school science situated event, in that it was both a useful learning context, and a potential barrier because of the few opportunities to bridge and leverage the various out-of-school aspects of Brenda's science-related learning pathways.

We have argued for the value of longitudinal learning research that investigates details of the same person's learning across settings and over time. Better understanding the learning related affordances, constraints, and practices of any situated event in which persons are engaged in sociomaterial activity is important in terms of better understanding how people learn out in the world, and across multiple social settings over time (and then thinking about the pedagogical implications of that). We contend that understanding the learning related affordances, constraints, and practices of linked situated events over various timescales is invaluable. We present the Cultural Learning Pathways Framework as one tool for analyzing those types of data.

Notes

¹Any metaphor is limited in its explanatory scope, and can be fraught with unexamined assumptions. Although beyond the scope of this particular analysis, the field might choose to critically examine what it means to call this space–time construction a learning pathway versus a learning trajectory versus a learning progression versus a pipeline (cf. Metcalf, 2010). We have chosen “learning pathway” because it implies some agency on the part of the traveler, and those who are supporting the traveler.

²All names are pseudonyms.

³Transcript conventions used in this paper (cf. Jordan & Henderson, 1995): double parentheses (()) = gesture, actions, and laughter; single parentheses () = dialogue is inaudible or uncertain; brackets [] = clarifying notes; double slash// = overlapping or interrupting talk; ellipsis (. . .) = words or turns of talk omitted for clarity.

⁴We provided a list of science-related kits (e.g., culturing bacteria, dissecting owl pellets, building a robot), and asked participants to choose the kit that they wanted to explore. Like Brenda, many of the participants chose kits that “fit” into a much larger activity system that was already in place. For example, a participant who was very interested in engineering and design selected the robotics kit.

⁵We would like to thank Kevin Leander for providing feedback on an earlier version of this manuscript.

⁶At the time of the study, we were prevented by our Institutional Review Board from sharing information we learned outside of school with teachers, and from sharing with participating families information that teachers relayed to us.

References

- Azevedo, F. S. (2013). The tailored practice of hobbies and its implication for the design of interest-driven learning environments. *Journal of the Learning Sciences*, 22(3), 462–510.
- Bang, M., Medin, D., Washinawatok, K., & Chapman, S. (2010). Innovations in culturally-based science education through partnerships and community. In M. Khine & I. Saleh (Eds.), *New science of learning: Cognition, computers, and collaboration in education* (pp. 569–592). New York, NY: Springer.

- Banks, J. A., Au, K. H., Ball, A. F., Bell, P., Gordon, E. W., Gutiérrez, K. D. . . . , Zhou, M., (2007). *Learning in and out of school in diverse environments: Life-long, life-wide, life-deep*. Seattle, WA: The LIFE Center and The Center for Multicultural Education, University of Washington.
- Barron, B. (2006). Interest and self-sustained learning as catalysts of development: A learning ecology perspective. *Human Development*, 49, 193–224.
- Barron, B., Martin, C.K., Takeuchi, L., & Fithian, R. (2009). Parents as learning partners in the development of technological fluency. *International Journal of Learning and Media*, 1(2), 55–77.
- Bell, P., Bricker, L. A., Reeve, S., Zimmerman, H. T., & Tzou, C. (2012a). Discovering and supporting successful learning pathways of youth in and out of school: Accounting for the development of everyday expertise across settings. In B. Bevan, P. Bell, R. Stevens, & A. Razfar (Eds.), *LOST opportunities: Learning in and out of school time* (pp. 119–140). London, UK: Springer.
- Bell, P., Tzou, C., Bricker, L. A., & Baines, A. D. (2012b). Learning in diversities of structures of social practice: Accounting for how, why and where people learn science. *Human Development*, 55, 269–284.
- Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.
- Bricker, L. A., & Bell, P. (2012). “GodMode is his video game name”: Situating learning and identity in structures of social practice. *Cultural Studies of Science Education*, 7(4), 883–902.
- Bricker, L.A., Reeve, S., & Bell, P. (in press). “She has to drink blood of the snake”: Culture and prior knowledge in sciencelhealth education. *International Journal of Science Education*.
- Brickhouse, N. W. (2010). Science as a way of leaving home. In K. Scantlebury J. B. Jahle & S. N. Martin (Eds.), *Re-visioning science education from feminist perspectives: Challenges, choices, and careers* (pp. 57–63). Rotterdam, The Netherlands: Sense Publishers.
- Bruner, J. (1996). Foreword. In B. Shore (Ed.), *Culture in mind: Cognition, culture, and the problem of meaning*. New York, NY: Oxford University Press.
- Calabrese Barton, A. (2003). *Teaching science for social justice*. New York, NY: Teachers College Press.
- Carlone, H., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44(8), 1187–1218.
- Chin, C. (2007). Teaching questioning in science classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching*, 44(6), 815–843.
- Clark-Ibanez, M. (2004). Framing the social work with photo-elicitation interviews. *The American Behavioral Scientist*, 47(12), 1507–1527.
- Crismond, D. P., & Adams, R. S. (2012). The informed design teaching and learning matrix. *Journal of Engineering Education*, 101(4), 738–797.
- Derksen, M. (2010). People as scientific instruments. *Spontaneous Generation*, 4(1), 21–29.
- Dewey, J. (1900/1902/1990). *The school and society: The child and the curriculum*. Chicago, IL: The University of Chicago Press.
- Dreier, O. (2008). *Psychotherapy in everyday life*. Cambridge, UK: Cambridge University Press.
- Dreier, O. (2009). Persons in structures of social practice. *Theory & Psychology*, 19, 193–212.
- Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.) *Handbook of research on teaching* (3rd ed.). (pp. 119–161). New York, NY: Macmillan Publishing Company.
- Gee, J. P. (2011). *An introduction to discourse analysis: Theory and method* (3rd ed.). New York, NY: Routledge.
- Gentner, D. (2001). Spatial metaphors in temporal reasoning. In M. Gattis (Ed.) *Spatial schemas in abstract thought* (pp. 203–222). Cambridge, MA: MIT Press.
- Geertz, C. (1973). Thick description: Toward an interpretative theory of culture. In *The interpretation of cultures: Selected essays* (pp. 3–30). New York, NY: Basic Books.
- GiddyUp. (2011). *The perfumery*. Ann Arbor, MI: Elmer’s Products, Inc.
- Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago, IL: Aldine Publishing Company.
- Glesne, C. (1999). *Becoming qualitative researchers: An introduction* (2nd ed.). New York, NY: Longman.

- Gonsalves, A., Rahm, J., & Carvalho, A. (2013). "We could think of things that could be science": Girls' re-figuring of science in an out-of-school-time club. *Journal of Research in Science Teaching*, 50(9), 1068–1097.
- González, N., Moll, L., & Amanti, C. (2005). *Funds of knowledge: Theorizing practices in households, communities and classrooms*. Mahwah, NJ: Erlbaum.
- Goodwin, C. (1994). Professional vision. *American Anthropologist*, 96(3), 606–633.
- Gutiérrez, K. D., & Rogoff, B. (2003). Cultural ways of learning: Individual traits or repertoires of practice. *Educational Researcher*, 32(5), 19–25.
- Harré, R., Moghaddam, F. M., Cairnie, T. P., Rothbart, D., & Sabat, S. R. (2009). Recent advances in positioning theory. *Theory and Psychology*, 19, 5–31.
- Harré, R. (2010). Equipment for an experiment. *Spontaneous Generations*, 4(1), 30–38.
- Henze, R. C. (1992). *Informal teaching and learning: A study of everyday cognition in a Greek community*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Heyl, B. S. (2001). Ethnographic interviewing. In P. Atkinson A. Coffey S. Delamont J. Lofland & L. Lofland (Eds.), *Handbook of ethnography* (pp. 369–383). London, UK: Sage.
- Hidi, S., & Renninger, K. (2006). The four-phase model of interest development. *Educational Psychologist*, 42, 111–127.
- Holland, D., & Leander, K. (2004). Ethnographic studies of positioning and subjectivity: An introduction. *Ethos*, 32(2), 127–139.
- Holland, D., & Lave, J. (2009). Social practice theory and the historical production of persons. *Actio: An International Journal of Human Activity Theory*, 2, 1–15.
- Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: The MIT Press.
- Ito, M., Baumer, S., Bittanti, M., Boyd, D., Cody, R., Herr-Stephenson, B. . . . , Tripp, L., (2010). *Hanging out, messing around, and geeking out: Kids living and learning with new media*. Cambridge, MA: The MIT Press.
- Johnson, A., Brown, J., Carlone, H., & Cuevas, A.K. (2011). Authoring identity amidst the treacherous terrain of science: A multiracial feminist examination of the journeys of three women of color in science. *Journal of Research in Science Teaching*, 48(4), 339–366.
- Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *The Journal of the Learning Sciences*, 4(1), 39–103.
- Latour, B. (2005). *Reassembling the social: An introduction to actor-network theory*. New York, NY: Oxford University Press.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.
- Leander, K. M., & McKim, K. K. (2003). Tracing the everyday "sittings" of adolescents on the internet: A strategic adaptation of ethnography across online and offline spaces. *Education, Communication, and Information*, 3(2), 211–240.
- Lemke, J. L. (1990). *Talking science: Language, learning, and values*. Westport, CT: Ablex Publishing.
- Lemke, J. L. (2010). Affect, identity, and representation. In K. Gomez, L. Lyons, & J. Radinsky (Eds.), *Proceedings of the ninth international conference of the learning sciences*. Chicago, IL: International Society of the Learning Sciences, Inc.
- Lim, M., & Calabrese Barton, A. (2010). Exploring insideness in urban children's sense of place. *Journal of Environmental Psychology*, 30, 328–337.
- Lynch, M. (1993). *Scientific practice and ordinary action: Ethnomethodology and social studies of science*. Cambridge, UK: Cambridge University Press.
- Metcalf, H. (2010). Stuck in the pipeline: A critical review of STEM workforce literature. *InterActions: UCLA Journal of Education and Information Studies*, 6(2), Article 4, 1–20.
- Nasir, N. S. (2000). "Points ain't everything": Emergent goals and average and percent understandings in the play of basketball among African-American students. *Anthropology and Education Quarterly*, 31(3), 283–305.

- Nasir, N. S., Rosebery, A. S., Warren, B., & Lee, C. D. (2006). Learning as a cultural process: Achieving equity through diversity. In R. K. Sawyer (Ed.) *The Cambridge handbook of the learning sciences* (pp. 489–504). Cambridge, UK: Cambridge University Press.
- National Research Council. (2006). *America's lab report: Investigations in high school science*. Washington, DC: National Academies Press.
- National Research Council. (2009). *Learning science in informal environments: People, places, and pursuits*. Washington, DC: National Academies Press.
- National Research Council. (2012). *A framework for K-12 science education: Practices, cross-cutting concepts, and core ideas*. Washington, DC: National Academies Press.
- NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC: Achieve, Inc.
- Ochs, E., Schegloff, E., & Thompson, S. (Eds.). (1996). *Interaction and grammar*. Cambridge, UK: Cambridge University Press.
- Reeve, S., & Bell, P. (2009). Children's self-documentation and understanding of the concepts "healthy" and "unhealthy." *International Journal of Science Education*, 31(14), 1953–1974.
- Rosebery, A., Warren, B., Ballenger, C., & Ogonowski, M. (2005). The generative potential of students' everyday knowledge in learning science. In T. Romberg, T. Carpenter, & F. Dremock (Eds.), *Understanding mathematics and science matters* (pp. 55–80). Mahwah, NJ: Lawrence Erlbaum Associates.
- Rouse, J. (1995). Engaging science through cultural studies. *Philosophy of Science Association*, 2, 396–401.
- Schwab, J. (1960). The teaching of science as enquiry. In J. Schwab & P. Brandwein (Eds.), *The teaching of science* (pp. 3–103). Cambridge, MA: Harvard University Press.
- Sismondo, S. (2010). *An introduction to science and technology studies* (2nd ed.). Malden, MA: Wiley-Blackwell.
- Steele, C. M. (2010). *Whistling Vivaldi: How stereotypes affect us and what we can do*. New York, NY: W.W. Norton & Company, Inc.
- Steele, D. M. & Cohn-Vargas, B. (2013). *Identity safe classrooms: Place to belong and learn*. Thousand Oaks, CA: Corwin.
- Tan, E., Calabrese Barton, A., Kang, H., & O'Neill, T. (2013). Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice in science. *Journal of Research in Science Teaching*, 50(10), 1143–1179.
- Tzou, C., Bricker, L. A., & Bell, P. (2007). *Micros and me: A fifth-grade science exploration into personally and culturally consequential microbiology*. Seattle, WA: Everyday Science & Technology Group, University of Washington.
- Tzou, C. T., & Bell, P. (2012). The role of borders in environmental education: Positioning, power and marginality. *Ethnography and Education*, 7(2), 265–282.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
- Warren, B., Ballenger, C., Ogonowski, M., Rosebery, A., & Hudicourt-Barnes, J. (2001). Rethinking diversity in learning science: The logic of everyday sensemaking. *Journal of Research in Science Teaching*, 38, 529–552.
- Wilson, R. E., & Kittleson, J. (2013). Science as a classed and gendered endeavor: Persistence of two white female first-generation college students within an undergraduate science context. *Journal of Research in Science Teaching*, 50(7), 802–825.
- Wortham, S. (2004). The interdependence of social identification and learning. *American Educational Research Journal*, 41, 715–750.
- Wortham, S. (2005). *Learning identity: The joint emergence of social identification and academic learning*. New York, NY: Cambridge University Press.
- Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Los Angeles, CA: Sage.
- Zimmerman, H. T. (2012). Participating in science at home: Recognition work and learning in biology. *Journal of Research in Science Teaching*, 49(5), 597–630.