BOLD VISIONS IN EDUCATIONAL RESEARCH

Identity Construction and Science Education Research

Learning, Teaching, and Being in Multiple Contexts

Maria Varelas (Ed.)

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BOLD VISIONS IN EDUCATIONAL RESEARCH
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MARIA VARELAS

1. INTRODUCTION: IDENTITY RESEARCH AS A TOOL FOR DEVELOPING A FEELING FOR THE LEARNER

> What is it in an individual scientist's relation to Nature that facilitates the kind of seeing that eventually leads to productive discourse?...Over and over again, she [Barbara McClintock] tells us one must have the time to look, the patience to "hear what the material has to say to you," the openness to "let it come to you." Above all, one must have "a feeling for the organism."
>
> – Evelyn Fox Keller

> The idea begins to live, that is, to take shape, to develop, to find and renew its verbal expression, to give birth to new ideas, only when it enters into genuine dialogic relationships with other ideas, with the ideas of others.
>
> – Mikhail Bakhtin

This book is about identity research. Beyond this introductory chapter, it contains 12 chapters that help us engage with aspects, dimensions, facets of students' and teachers' identity construction vis-à-vis science education and with ways that can be fruitful for examining identity and identity construction. But why should science educators be concerned with identity and identity construction? And why may a book like this one promote our understanding of identity and identity construction?

I argue that the answers to these two questions closely relate to the two quotes offered above by two particularly influential scholars who made brilliant contributions in very different fields–Barbara McClintock in genetics, and Mikhail Bakhtin in literary theory. The ideas of identity and identity construction may help us develop "a feeling for" the learner, and lead to productive discourse about learning and teaching. Sharing and discussing, as we do in this edited volume, research of scholars who study identity work in various science education contexts, with various people, and for various purposes, may augment dialogic relationships among identity-related ideas especially as they relate to the field of science education.

Identity is a multidimensional, multifaceted, and complex construct receiving increasingly more attention in science education. The multiple identities that students and teachers bring with them *and* further construct and re-construct in

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classrooms and out-of-school settings allow them to be, and be recognized as, particular types of people, act in particular ways, encounter opportunities and barriers, and, thus, experience successes and challenges in learning. This frame of thinking aligns with a socio-cultural, interactionist perspective that all authors adopt in their chapters, and is evident in the theoretical frameworks that have guided the various studies and in the ways in which data have been collected, analyzed, and synthesized, and in the chapters containing commentaries. As students, or learners in general, learn science and teachers, or facilitators in general, teach or engage them in science, learners and teachers unavoidably (re)construct identities–who they are, who they are becoming, who they want to be and become vis-à-vis science as a practice, a discipline, a field of study, a school subject. Identity construction is intimately related to learning and teaching, educating and being educated.

A quick query on articles that have been published in the two highest-ranking science education journals, the *Journal of Research in Science Teaching* and *Science Education*, reveals that "identity" is used in the title of 22 and 19 articles respectively, mostly since 1998 with a surge in the last few years. This number is higher (37), almost twice the average of the other two numbers, for the relatively newly established (5 years now) journal of *Cultural Studies in Science Education*, dedicated to providing a forum for researchers who study science education from a cultural lens. Although absence of reference to a construct in the title of a paper does not, of course, necessarily imply that the construct is neither relevant nor important in that scholarly contribution, its presence strongly positions a paper as addressing, and focusing on, identity and/or identity work. I interpret these numbers to mean that there is interest in the science education community for research related to identity and its relationship with teaching and learning of science, but also that the field has room to grow relative to this domain. We hope this book is a meaningful contribution towards this goal.

A FEELING FOR THE LEARNER

Let me return to Barbara McClintock and her revolutionary work in genetics to argue that focusing on identity and identity construction, along with learning content, may help us see learning in a whole new light. It may help us acquire a feeling for the learner that encompasses multiple dimensions of being in the world–social, relational, cognitive, rational, affective, emotional, behavioral, cultural, racial, and so on and so forth.

McClintock went "against the grain" to argue, and show with her work, that scientists' understandings about ways in which things work may be rather limited unless the objects of their study (an organism in her case) is approached from the inside, in a holistic way, and in a way that honors its complexity and its own internal organization and consistency. In order to study Indian corn and reach several groundbreaking ideas related to how genes affect each other and get transported within DNA, like the idea of "jumping genes" or transposons in scientific terminology, she had to have an awareness of the oneness of a grain of

corn, appreciate difference, notice relationships between different parts, and become part of the system. McClintock showed us how plants do things for their survival, how they make their own sense, so to speak. She pointed out the astonishing diversity and inconceivable resourcefulness of the order inside an organism. And she achieved this because she delved deeper inside the organism, watching it grow. "I don't feel I really know the story if I don't watch the plant all the way along" (quoted in Keller, 1983, p. 198).

For McClintock, no two plants are alike, they are all different, and she had to know the difference by imagining herself in the life of the plants she was studying. Moreover, McClintock recognized that, in order to understand an organism deeply, scientists need to first accept that its complexity may be too vast to comprehend, which further implied for her that reason alone could not do justice to this complexity. She linked this complexity to an organization within an organism that enables it to live and meet its needs, a kind of integration inside the organism. Thus, she believed that "we're going to have a completely new realization of the relationship of things to each other" (quoted in Keller, 1983, p. 207), if we reorganize the way we look at things. According to Keller, McClintock showed us that "the ultimate descriptive task, is to 'ensoul' what one sees, to attribute to it the life one shares with it; one learns by identification" (p. 204).

Keller also highlighted that McClintock was very cognizant of the fact that so far science had been mostly influenced by, and reflected, western perspectives about knowing that were based on objective assessments of the world. McClintock's perspective was different; she believed that a hybrid perspective which embraces various ways of knowing is more fruitful, including Eastern perspectives that pay attention to both spectators' and actors' points of view. Finally, it is worth pointing out that McClintock conducted her studies with a crop that was not popular because it cannot be grown more than twice a year. However, she realized that if she was to study it in the way described above, one crop was what she needed and she could manage.

Similarly to McClintock's call for science researchers to develop a feeling for the organism, education researchers may benefit from developing a feeling for the learner in order to deeply understand how learning of, engagement with, involvement in, and relation with science successfully takes place in and out of school classrooms. Identity may be a construct that could get us closer to such a goal.

The construct of identity has been explored and used extensively in various social science disciplines and is defined in different ways. A sociological approach to identity assumes a reciprocal relationship between self and society–the self emerges in and is reflective of society, and the self influences society through the actions of individuals (Stryker, 1980). The construct of identity is different from the construct of self. "In general, the self-concept is the set of meanings we hold for ourselves when we look at ourselves. It is based on our observations of ourselves, our inferences about who we are, based on how others act toward us, our wishes and desires, and our evaluations' of ourselves" (Stets & Burke, 2002, p. 130). However, identities are parts of self that are defined by the different

positions we hold in society. They are the "meanings one has as a group member, as a role-holder, or as a person" (Stets & Burke, 2002, p. 132). Identity is an "internalized positional designation" (Stryker, 1980, p. 60), and, thus, by default tied to aspects of social structure. Identity is embedded in social experience, symbolic communication, and reflection of institutional practices, but it is also under agentic control.

Thus, studying identity and identity construction allows us to understand a learner from a relational perspective along with the relational character of learning. Identities shape, and are shaped by, inclusion and exclusion relationships in a social structure where relations of alliance, dominance, or subordination, that are formed among a learner, other members of the social structure, and the nature of the activity in that structure, influence participation, knowledge development, emotions, and actions. As learners find themselves in, or intentionally become part of, these structures, they come to develop what Cotê and Levine (2002) called "identity capital"–"capital associated with identity formation, namely, the various resources deployable on an individual basis that represent how people most effectively define themselves and have others define them, in various contexts" (p. 142). In order to come closer to developing a more holistic understanding of learning and teaching science, defined broadly to include developing knowledge of content along with positive relations with science and scientists, we need to better understand identity construction.

The various chapters in this book focus on such understanding studying various aspects of identity construction at various contexts and with various learners and teachers. However, all the chapters reflect, I believe, some of the fundamental commitments in McClintock's scientific research noted earlier. This scholarship on identity work assumes and explicates the complexity of the ways in which learners and teachers develop identities, the difference among a person's multiple identities and among identities of different people, the interaction between structure and agency, and the time dimension of research on identity work. Focusing on identity work allows us to come closer to knowing a learner or a teacher intimately in ways that the person becomes the center, not our propositions about the person, the work, the knowledge, the learning and teaching. We have to pay attention to what people, themselves, do, how they see themselves, how emotion and reasoning is intertwined in the way they think, behave, act, and be, and how they make their own what others think of them along with the norms and expectations of a social structure.

Moreover, the identity work explored in this book mostly concerns students or teachers with racial, ethno-linguistic, class, academic status, and gender affiliations that have been long excluded from, or underrepresented in, scientific practice, science fields, and science-related professions, or have been positioned as facing difficulties in learning, and succeeding in, science. Although such populations may have only relatively recently attracted increasing attention due to many various factors (sociopolitical, ideological, ethical, practical), they provide rich opportunities to explore how intricately related identity and identity construction are to learning and teaching science given that, as Foucault (1994/2000) noted,

power is not possessed by individuals, but is constituted by, and enacted through, social relationships.

DIALOGIC CONSTRUCTION OF UNDERSTANDINGS

This book started from an interactive poster symposium that a group of us offered at the 2010 AERA (American Educational Research Association) annual conference. As science education researchers, we had all been doing research related to identity and identity construction, studying various aspects of it and in various contexts, and thought the conference would give us an opportunity to discuss and further develop our ideas. The final content of the book reflects understandings developed by the authors individually and collectively influenced by various dialogic exchanges.

At the conference, the authors had the chance to discuss, elaborate, and further develop their ideas as they interacted with audience members who visited their posters during the session. In addition, during the final part of the session, audience and symposium participants engaged in a discussion on the various dimensions of identity studied in each of the research studies. Two colleagues, Greg Kelly and Nancy Brickhouse, who served as discussants at the symposium, have offered in the book commentaries on these studies, pulling together threads, posing questions, and offering points for further consideration. Each has primarily focused on one of the two parts of the book, each consisting of five studies. Finally, as the editor I flagged for authors areas in their chapters that may benefit from further articulation which the authors have graciously undertaken. This, in a nutshell, captures the dialogic construction of ideas shared in this book.

Identity is not a new construct and it has been studied in a variety of disciplines. In this volume, we consider identity-related ideas in learning and teaching of science. This, I believe, gives us an opportunity to juxtapose identity-related ideas with science as a practice, and with science learning and teaching as opportunities to develop awareness of, and competence in, some of its content and practices, and to socialize into this practice. The chapters in this book address various ideas related to identity and identity work, including normative practices, multiple identities, identity stories, science identity, counter-narratives, positionality, subjectivities, self-authoring, agency, structure, power, social justice, emotions, authority, competence, performance, smartness, equity, access, identity trajectories, success.

By identifying this as an opportunity, I do not imply that these various ideas have not yet been explored in science education. However, I believe that identity and identity work can become a useful umbrella concept, a super-construct, which allows us to put together all these ideas and explore their possible relations and interactions. These ideas impact, and are impacted by, each other in various ways. Their dialogic dependence becomes more pronounced, encouraging exploration and systematic study, when they are all considered as part of a bigger whole, a whole that brings us closer to understanding learners and teachers as complex

wholes of reason, affect, social markers, a physical body, and relations with people and things.

In closing, I believe identity research may help us ask questions that we have not asked so far about how students learn science and how teachers teach science, or other adults engage them in science, in order to promote and ensure learning. I adopt Bakhtin's (1981) idea that words do not have meanings, but only meaning potentials that combine with various contextual factors to produce situated interpretations. Meaning potentials are affordances for meaning making, and although they may be partially stable, they are also changeable over time and activity. This is because meaning potentials depend on contexts, and thus can be modified, enriched, expanded, and differentiated as they are employed in different contexts. Similarly, I view the words used to describe the identity-related ideas discussed, studied, and problematized in the chapters of this book, as meaning potentials that, when situated within different science education contexts, may acquire new meanings and promote new understandings, discourse, and actions. It is my hope that this book generates many more meaning-potentials for ideas related to identity and identity construction.

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PART 1: K-12 SCIENCE LEARNERS IN AND OUT OF SCHOOLS

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2. METHODOLOGICAL CONSIDERATIONS FOR STUDYING IDENTITIES IN SCHOOL SCIENCE: AN ANTHROPOLOGICAL APPROACH

INTRODUCTION

Studying identity is a daunting task for new science education scholars. Part of the problem lies in the difficulty of theorizing the concept in rigorous, cohesive, and empirically accessible ways. When I teach qualitative research methods, my favourite question to ask students about their primary concept of interest is, "How will you know it when you see it?" Those studying identity inevitably have considerable difficulty answering this question. The purpose of this chapter is to provide methodological direction for those beginning the formidable task of studying identity in school science or for those who want to broaden their identity studies toolkit. This discussion will not remove the messiness of the concept, but I aim to bound the concept to make it a little less unruly. Of course, any boundary-defining attempts leave out other important, equally valid and rigorous, ways to bound the concept. The important thing is to understand the ways one bounds the concept and what is visible and veiled as a result.

In this chapter, I bound the concept of identity in distinctively anthropological ways. I explain social practice theory and its implications for identity research. This approach can be labelled "ethnography of personhood" (Holland, Lachicotte, Skinner, & Cain, 1998). I explain how studying individuals' identities in school science can productively take place in concert with a study of culture. In my research, I cannot completely address the question, "Who are individual students *becoming* in a setting?" unless I also address the question, "Who are students *obligated to be* in a setting?" I provide examples from my research in school science settings and methodological tools to illustrate how I get at the latter question. Then, zooming in the lens further, I provide readers with specific data collection strategies and analytic codes that have been helpful in my own work to characterize students' identity work in school science. With additional examples from my research, I argue that my quest to understand the classroom culture provides insights about students' identity work that would be masked otherwise.

SOCIAL PRACTICE THEORY

The chapter is framed from a social practice theory lens that arises from the work of anthropologists of education (Eisenhart & Finkel, 1998; Holland, et al., 1998;

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Holland & Lave, 2009; Wortham, 2006). Social practice theory emphasizes the notion of cultural production, the ways cultural meanings are produced in everyday practice in ways that reflect and/or counter larger social structures (Eisenhart & Finkel, 1998). One assumption about identity, then, is that people are formed in practice. What does it mean to be a smart student? A struggling student? A discipline problem? A good athlete? These meanings are context dependent, formed in local practice and draw on histories of practice like schooling. Some students who engage happily in traditional school science practices of taking notes, paying attention, memorizing facts, and following directions often get labelled "good students." These students may resist practices (problem-solving, risk-taking, engaging in scientific argumentation) and the accompanying implied identities that threaten their good student identities. The identity outcomes of any given set of practices are sometimes, but not always, heavily shaped by larger social structures. People author themselves in imaginative ways, "writing meaning, rather than simply receiving it" (Giroux, 2006, p. 128). This also implies a political struggle over the meanings of schooling, science education, and scientifically literate student.

In social practice theory studies of identity, the concept of practice serves as a way to recognize the co-development of the global and the local (Wortham, 2006). Social practice theory is, in part, a response to the classic structure/agency problem of educational research, acknowledging that becoming "somebody" is not completely a matter of individual choice (agency), nor is it solely determined by macro-level social structures like race, class, and gender. Studying identities in schools does not simply mean identifying "dominant ideological interests at work that serve to oppress teachers and students" (Giroux, 2006, p. 127), nor does it mean ignoring those interests as we strive to understand students' identities. Instead, we question how those interests function, produce particular ways of life, and are taken-up. Indeed, the potential of identity to reconcile the micro- and the macro- is part of its allure: identity can account for "individual agency as well as societal structures that constrain individual possibilities" (Brickhouse, 2000, p. 286).

Recent equity research in science education has drawn on perspectives from sociology (e.g., Sewell, 1992) and/or cognitive anthropology (e.g., Holland, et al., 1998) to broaden purely psychological perspectives. Doing so allows recognition of the ways micro-, meso-, and macro-levels of structure (Tobin, in press) enable and constrain individual and group-level accomplishments in/of science education. An example of structure is the normative (group-level) practices, beliefs, and values that give meaning to, enable, and constrain individuals' behaviours (Shanahan, 2009). Structure also refers to more macro-level processes and meanings, like those implied by history, politics, economics, and social structures of race, class, and gender. For example, in Nancy Brickhouse and colleagues' work (2000), the historically enduring model of "loud black girl" (Fordham, 1993) inhibited others' recognition of a scientifically talented girl who did not fit into established meanings of "good" (i.e., obedient, quiet) student. Structure bears down on local practice, enabling some meanings and constraining others, but it is

also continually produced in everyday practices. Classic studies in anthropology of education, for example, discuss the ways schooling practices reproduce social and economic inequities. Oakes' work (1985) illustrates this point; she examined the ways that the practice of ability-level tracking reproduces society's racial and class inequities in the US.

Attention to structure, however, without recognition of agency points to an overly deterministic explanation for what happens in schools and in science learning settings. Roth & Tobin (2007) argue similarly for recognizing the dialectic between agency and structure as we understand how people form identities in and through science learning. Recognizing the structure/agency dialectic, as Shanahan (2009) argued, "poses methodological problems" (p. 46) and, in sociocultural studies, often veers too far over on the "agency" side to over-emphasize the freedom individuals have to shape their own destiny, to make their own meanings (Lewis & Moje, 2003). Shanahan (2009) argued that much of the identity literature in science education can be critiqued similarly:

> The agency of individuals therefore works within, through and against social structural constraints. Despite the recognition of the interplay between structure and agency in the identity literature and its underlying theoretical frameworks, most studies aimed at furthering our understanding of identity and its attendant processes have focused on aspects related to the individual and especially to individual agency. (p. 44)

Though we gain solid insight from examining and theorizing moments of agency, creativity, and improvisation, science education needs more accounts of the ways group-level meanings–heavily influenced by larger social structures, history, and politics–emerge and enable and constrain individuals' subject positions. There are different timescales at work in processes of social identification (Wortham, 2006). Studying identity might involve attention to *moments of authoring* oneself in imaginative ways that may or may not lead to more *enduring, habitual performances of self* and/or *transformations of the cultural meanings of science person* within a local group that become *resources for the culture of future groups* (Wortham, 2006). Each perspective in italics above implies a different timescale and/or unit of analysis. Suddenly, the notion of "forming identities in practice" becomes even more complicated.

Thus far, I have discussed three theoretical assumptions about identity that emerge from a social practice theory lens. First, identities are formed in practice. Second, people have a say in who they become (agency), but that agency is often limited by historical, social, institutional, and local structures (Holland, et al., 1998). Third, social identification occurs within and is influenced by multiple timescales; in the moment, over months-long periods of time, over years, and over generations. In this chapter, I privilege the study of identity over a months-long and years-long timescale, which is consistent with an ethnography of personhood. My approach to studying identity outlined in this chapter could be critiqued for over-emphasizing structure. However, this approach heeds Wortham's (2006) argument that the meso-level timescale is the most often overlooked in considering

processes of social identification, Shanahan's (2009) argument that influences of structure are under-examined in identity studies in science education, and Holland and colleagues' (1998) insistence that people's agency in authoring their own identity should not be over-stated: "The space of authoring, of self-fashioning, remains a social and cultural space, no matter how intimately held it may become. And, it remains, more often than not, a contested space, a space of struggle" (p. 282).

METHODOLOGICAL CONSIDERATIONS FOR STUDYING IDENTITY

Who Are Students Obligated to Be? Normative Scientific Identities

I begin my studies of identity by characterizing the cultural production of the "celebrated" or "normative" science person in the research setting. These are group-level meanings, produced in everyday practice, of a science person. Those trained in psychological traditions, trained to pay attention to individual outcomes, may at first be challenged by a focus on *group-level* meanings. It may help to consider this a matter of lens-shifting. Rather than ask, "What are individual students learning or who are they becoming?" shift the lens to ask, "Who are students obligated to be?" Rather than ask, "Who's struggling?" shift the lens to ask, "What does it mean to struggle? What is the struggle about? How is 'struggling' defined?" Rather than ask, "Who's successful?" ask, "What does it mean to be successful? What opportunities does the setting provide for individuals to become successful?" When I argue for a focus on group-level meanings, I do not mean that these are meanings held by or equally accessible to every member of the group. With an anthropological lens, one examines group-level meanings that structure the group's activities, that define "normal" behaviour for the group, that hold most sway in defining who gets to be counted as a legitimate group member.

This lens-shifting requires a situated definition of scientific competence (Gresalfi, Martin, Hand, & Greeno, 2008; Lottero-Perdue & Brickhouse, 2002) that raises questions about what students have to do to be considered competent in a setting. In this view, competence is not viewed as an individual trait, but involves interaction between students' opportunities to participate competently and the meanings they make of those opportunities (Carlone, Haun-Frank, & Webb, 2011; Gresalfi, et al., 2008). There is no one set definition of "scientific investigation" or "scientific knowledge" or "scientific person." Many in science education would not argue with this point, but too few take it seriously in their research. Science education research often begins with *a priori* definitions, usually the researchers', of what counts as "good" science, teaching, and student. When the research participants' definitions are considered, they are often done so to measure how closely the participants' meanings align with the *a priori*, more "desirable" meanings. For example, research that examines participants' understandings of the nature of science most often assumes certain definitions of the nature of science. Similarly, research that examines teachers' enactment of inquiry-based instruction measures their enactment against a standard. I do not argue here about the value of this kind of research, but use these as examples to demonstrate the pervasiveness

of privileging *a priori* meanings of scientific investigation, knowledge, and person in science education research. The struggle, then, is to unlearn this tendency of assumption-making and learn to see the value in asking, "What counts as science and science person *in this setting*?" (Kelly, Chen, & Crawford, 1998).

Further, this lens requires a situated definition of "practice," which is, in part, locally produced and interactionally defined by actors in the setting and also implies more powerful, historical traditions. In the case of a science classroom, practices have sociohistoric legacies associated with schooling and disciplinary legacies associated with science. Greg Kelly (2008) explained that a "practice is constituted by a patterned set of actions, typically performed by members of a group based on common purposes and expectations, with shared cultural values, tools, and meanings" (p. 99). Thus, it is possible to view school scientific practices, and the accompanying identities produced in practice, as emergent phenomena that are shaped by historical traditions.

I label the scientific practices in which students are held accountable to be considered competent "normative scientific practices" after Paul Cobb, Melissa Gresalfi, and colleagues (Cobb, Gresalfi, & Hodge, 2009; Gresalfi, et al., 2008; Gresalfi & Cobb, 2006) who coined the phrase "normative mathematical practices." Methodologically, then, we can study the scientific and social practices that emerge as important, over a weeks-long or months-long timescale. This timescale analysis is neither micro-level (e.g., as are the in-the-moment- and event-levels), nor is it a macro-level. Actors develop local (meso-level) models of smart or "sciencey" students and habitually apply these to given students and/or author themselves within and against these models over the year (Carlone, Kimmel, Lowder, Rockford, & Scott, 2011; Wortham, 2006).

A situated definition of competence means that students become "certain kinds" of students within the context of what counts as science in a setting. A "know-it-all" student in one setting might be lauded as talented and smart, but in another setting might be considered too close-minded, dependent on authoritative sources, and not willing to take enough risks to be considered a good science student. Normative scientific practices imply normative scientific identities. Cobb, Gresalfi, & Hodge (2009) coined the term normative identity for mathematics, but the term "scientific" can be substituted for their use of "mathematical" in their definition:

> Normative identity as we define it comprises both the general and the specifically mathematical obligations that delineate the role of an effective student in a particular classroom. A student would have to identify with these obligations in order to develop an affiliation with classroom mathematical activity and thus with the role of an effective doer of mathematics as they are constituted in the classroom. Normative identity is a collective or communal notion rather than an individualistic notion. (pp. 43–44)

Why is it important to question what counts as science and science person? In questioning what counts or in "making the familiar strange" (Spindler, 1982), one is able to make visible structures, norms, and celebrated and marginalized practices previously hidden. This, in turn, sheds light on the accessibility of the setting's

normative science identities. Hammond & Brandt (2004) argue similarly: "Through considering the 'hidden agendas' of these institutions [like schools], it becomes possible to see how disenfranchised groups, such as girls, immigrants, and underrepresented minorities, might experience them" (p. 8). Questioning what counts: (1) denaturalizes scientific competence; (2) provides insight about accessibility of locally produced science and science person for a wide range of students; and (3) illuminates the subject positions science learners are afforded in practice.

An Example

A recent example from my comparative ethnographic research of two fourth-grade classrooms highlights this point more clearly (Carlone, et al., 2011a). In this study, both classroom teachers (Ms. Wolfe and Mrs. Sparrow) were equally committed to reform-minded science, adept with classroom management, regularly engaged their students in empirical investigations of a scientific question in small groups, and expressed beliefs that good science instruction disrupted hierarchies among students. On assessments, students in both classrooms performed comparably and expressed positive attitudes about science. However, students' affiliation to the culturally produced meaning of "smart science student" in each classroom differed dramatically. In end of year interviews, students in Ms. Wolfe's classroom described the meaning of "smart science student" in broad, inclusive ways (e.g., as curious, a good observer, persistent, a good thinker, and someone who asks good questions). Further, all students either named themselves as one of smartest science students or they mentioned one or more characteristic that they shared with the students they identified as the smart science students. In other words, the students' meanings of "smart science student" were accessible and believable for a broad range of students.

In Mrs. Sparrow's class, on the other hand, students' descriptions of "smart science student" more typically aligned with narrow, historically enduring meanings of school science (e.g., someone who answers the teacher's questions correctly, knows a lot of facts, pays attention, uses big words). The girls of colour in particular, all of who claimed to "like" science and one of whom performed at the top of the class on science assessments, immediately asserted that they did not share any characteristics with smart science students. In fact, they expressed outright disaffiliation with those they identified as the "smart science students": e.g., "*They're* the science people. We aren't like them."

In the original paper, we asked, "Why such different outcomes from such seemingly similar inputs?" What aspects of the cultural definition of "smart science student" alienated the girls of colour in Mrs. Sparrow's class? Their interviews provide only a starting point of explanation; as I explained above, cultural productions are *implicit* meanings produced in everyday practice. Thus, our commitments to question what counts led us to examine the cultural meanings of scientific knowledge, investigation, and person in each class through in-depth, participant observation of normative scientific practices.

Our analysis yielded striking evidence for different meanings of scientific knowledge, investigation, and person in each class. In Ms. Wolfe's class, *scientific investigation* meant trying out ideas together and examining questions that did not always have a specified endpoint, which opened up opportunities for more questions and investigation. *Scientific knowledge* was jointly constructed, social, and generative. Responsibilities for generating scientific knowledge were distributed across the whole class. A *scientific person* shared scientific ideas with others, built on and questioned others' ideas, disagreed politely with classmates, made careful, insightful observations, asked good questions, and were patient and active listeners of others' ideas. The cultural meaning of scientific person was in stark juxtaposition to the historically enduring "know-it-all" identity celebrated in many school science classrooms. In this case, the meaning of scientific person was broadly constructed, inviting and accessible to all students.

In Mrs. Sparrow's class, *scientific investigation* largely meant trying out one's own ideas with tools. It had a discrete endpoint; the purpose was to come up with "the" answer. Scientific knowledge, whether constructed in small or whole groups, was individually owned (e.g., "my" idea versus "our" idea). In small groups, that knowledge was often "kept secret" from other group members and/or from other groups until the teacher asked for it. A *scientific person*, therefore, was the one who most often produced the answers and was assertive in trying out her/his own ideas with tools. Science people, in this class, figured things out for themselves and did not necessarily get ideas from, or productively share ideas with, others. In this case, the meaning of science person was not equally accessible to all students; not everyone got a fair opportunity to be scientific.

This example helps illuminate the explanatory potential of beginning a study of identity by examining culturally produced meanings rather than jumping immediately to examine aspects of individual students' identities. Examining group-level meanings of science raises questions about the science that students are held accountable to know and do as well as science's viability and relevance for students with wide-ranging backgrounds, interests, and experiences. In the two classrooms, students were held accountable to different normative scientific practices. In Mrs. Sparrow's class, there were uneven expectations of and opportunities to perform these normative practices and identities.

Thus far, I presented an argument showing why and how examining normative scientific practices and identities is important, and I have provided an example of how that endeavor provided a rich explanatory potential when applied to the cases of Ms. Wolfe and Mrs. Sparrow. Below, I provide methodological tools that make this endeavor more concrete.

FIELDWORK STRATEGIES TO IDENTIFY NORMATIVE SCIENTIFIC PRACTICES AND IDENTITIES

Our commitments to cultural production and normative scientific practices led to our examination of what counted as scientific investigation, knowledge, and

person in Ms. Wolfe's and Mrs. Sparrow's classroom. But, what kinds of data did we collect? How did we get from fieldwork to interpretations? In this section, I provide some methodological tools that my research team and I use in our work.

This methodological process toggles back and forth between inductive and deductive strategies. Participant observation provides key insights needed to understand taken-for-granted meanings, produced in regularly-occurring, everyday practices, that structure people's behaviour, values, and knowledge. One has to "be there" to get at the "regularly-occurring", everyday practices. Once in the field, what should one observe? Spradley's (1980) classic participant observation questions provide a great starting point: What are people, saying, doing, and producing? Answering these questions demands participant observation, interviewing, and artefact collection. Of course, these questions may be too broad for one who does not have the luxury of daily observations over months and years; thus, further focus may be necessary to get the most out of the initial fieldwork. The trick is to observe with direction, but not rigidity, allowing for new, unexpected practices and meanings to emerge.

In the comparative ethnographic study of Ms. Wolfe's and Mrs. Sparrow's classrooms, we began with the overall questions: What counts as science in each classroom? What does it mean to be scientific in each classroom? We operationalized those questions by asking: (1) What are the regularly occurring scientific practices in each classroom? (2) What is the nature of the scientific practices in each classroom? (3) Who gets to be scientific? I describe procedures for answering each of these questions below.

1. Identify Regularly Occurring Scientific Practices in Each Setting

Though we did not want to apply a rigid *a priori* definition of science or science person, we had to begin with a theoretically informed definition of "scientific practice" to guide initial classroom observations. We used Kelly and Duschl's (2002) dimensions of scientific literacy (investigative, communicative, and epistemic practices) as a starting point and defined *practice* as a patterned set of actions performed by members of a group based on common purposes and expectations, with shared ways of talking and using tools (Kelly, 2007; Lave & Wenger, 1991). Our investigation of *scientific practices* focused on patterned sets of actions that dealt with inquiry (investigative), communication of scientific ideas (communicative), and justification, evaluation, and legitimization of knowledge claims (epistemic). At the beginning of each ethnographic study, we focused on the kinds of scientific practices that emerged as important in each classroom, rather than on individual students' competence and engagement with the practices. This broad definition of scientific practices guided our initial observation protocol (Table 1).

Table 1. Sample observation protocol for defining normative scientific practices

Over-riding questions for observations: What are students doing, saying, and producing? (Spradley, 1980)		
Scientific Practices		*Description and Examples*
	What are all the regularly occurring *investigative practices* in the setting? Put differently: What are all the ways students engage in scientific investigation?	Examine the ways students investigate scientific questions using empirical data and their prior knowledge. Examples: observation, data collection, problem solving, testing ideas.
	What are all the regularly occurring *communicative practices* in the setting? Put differently: What are all the ways students and teachers communicate?	Examine the ways students communicate (verbally or representationally) with each other and with their teacher during science. Examples: question-asking, generating/interpreting inscriptions, small- and whole-group discussions.
	What are all the regularly occurring *epistemic practices* in the setting? Put differently: What are all the ways students and/or teachers infer, justify, evaluate, and legitimate scientific knowledge?	Examine the ways that students and/or teachers infer, justify, evaluate, and legitimate scientific knowledge.

Note. These dimensions overlap, but I separate them here for analytic purposes. These are sample definitions and examples I find helpful as starting places for identifying normative scientific practices and identities.

2. Describe the Nature of the Scientific Practices in Each Setting

As we developed an initial list of scientific practices, our goal was to also develop "rich descriptions" (Geertz, 1973) of those practices and to understand the meanings of scientific investigation, knowledge, and person implied by those practices. The idea was to understand as much as we could about each emerging practice—e.g., the celebrated and marginalized ways of enacting the practice, the times and spaces for the practice, the person/people responsible for enacting the practices, and the purposes for enacting those practices.

Descriptive questions matrix. I developed a descriptive questions matrix (Adapted from Spradley, 1980; see Table 2) to provide direction for gathering information about the nature of scientific practices in a setting. This matrix was designed as a generative tool, one that can guide initial analysis and ongoing, more selective participant observations. Some of the questions on the matrix are directly observable (e.g., what are the times and spaces for the practices?), while others require initial analysis to answer (e.g., what are the purposes for the practices?).

Of all the ethnographic categories listed in Table 2, identifying the "celebrated and marginalized" ways to enact the practice (the first row of the table) is incredibly fruitful and efficient in lending insight into the meanings of scientific investigation, knowledge, and person. One can see the logical connection between (a) "what counts" as good observation, good scientific explanation, and good justification and (b) inferring meanings and accessibility of scientific investigation, knowledge, and person. Teachers and peers praise, encourage, correct, re-direct, and admonish; those instances are opportune moments to capture for later analysis. What kinds of answers to questions get praised and recognized? What kinds of student questions are praised and discouraged? What kinds of questions do teachers ask?

Norms and values card sort interview. In any study of culture, it is important to try to understand participants' meanings of the group's norms, practices, and values. I created the *norms and values card sort interview* to infer students' and teachers' understandings of and valuations of the normative scientific practices (Carlone, et al., 2011a; Cobb, et al., 2009). This interview technique serves as a form of "member checking" (Lincoln & Guba, 1985).

Once we have what we feel is a fairly good understanding of the normative scientific practices and the community values that help define what counts as science and who counts as science person in the setting, we produce a small stack of cards; each card contains a statement identifying a practice or value (Figure 1). Card statements represent what we have interpreted as central and marginal aspects of the classroom culture to guard against premature conclusions.

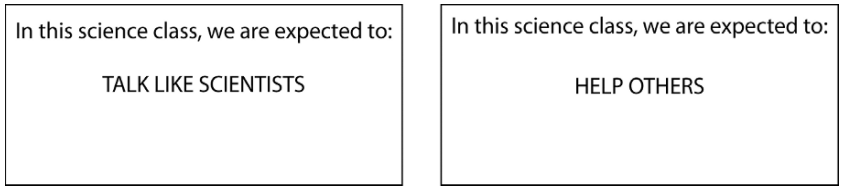

Figure 1. Examples of cards for the norms and values card sort interview protocol featuring a normative practice (left) and a value (right).

We engage participants with up to three tasks related to the card statements. For the first task, participants read each statement on the card and decide whether the statement represented something that they have to do regularly (for the practices) and/or something that was really important (for the values) to be considered a "good science student" in their classroom. They place the cards in a "yes", "maybe", and "no" pile. We ask: "What does it mean to [card statement here] in this class?" "Can you give an example of a time when you had to do that?"

Table 2. Sample descriptive question matrix (adapted from Spradley, 1980)

*Scientific practices** →		*Scientific Observation*	*Scientific Explanation*	*Review and Critique Scientific Knowledge*	*Justification*	*Legitimizing Science Ideas/Knowledge*
Sample Ethnographic Analytic Categories	Celebrated/ marginalized ways to do it	What are celebrated and marginalized ways to observe?	What are celebrated and marginalized ways to develop scientific explanations?	What are celebrated and marginalized ways to review/critique scientific knowledge?	What are celebrated and marginalized ways to justify scientific knowledge?	What are celebrated and marginalized ways to legitimize scientific ideas?
	Actor(s) (central and marginal)	Who observes? Who doesn't?	Who develops scientific explanation? Who doesn't?	Who reviews/critiques knowledge? Who doesn't?	Who justifies scientific knowledge? Who doesn't?	Who legitimizes scientific ideas? Who doesn't?
	Time	What are the times to observe? How often does it happen?	What are the times to develop explanations? How often does it happen?	What are the times to review and critique? How often does it happen?	What are the times for justifying scientific knowledge? How often?	What are the times for legitimizing scientific ideas? How often?
	Space	Where do scientific observations get made? With what arrangements of space and actors?	Where do explanations get developed? With what arrangements of space and actors?	Where does review and critique occur? With what arrangements of space and actors?	Where does knowledge get justified? With what arrangements of space and actors?	Where do ideas get legitimized? With what arrangements of space and actors?
	Tools	What tools are used to observe?	What tools are used to develop explanations?	What tools are used to review/critique?	What tools are used to justify knowledge?	What tools are used to legitimize scientific ideas?
	Talk (central and marginal)	What kind of is used/marginalized to make observations?	What kind of talk is used/marginalized to develop explanations?	What kind of talk is used/marginalized to review/critique?	What kind of talk is used/marginalized to justify knowledge?	What kind of talk is used/marginalized to legitimize scientific ideas?
	Artifacts	What artifacts are produced in the process of/as a result of observation?	What artifacts are produced in the process of/as a result of developing explanations?	What artifacts are produced in the process of/as a result of reviewing and critiquing?	What artifacts are produced in the process of/as a result of justifying knowledge?	What artifacts are produced in the process of/as a result of legitimizing ideas?
	Goals and Purposes	What are goals of and purposes for observation?	What are goals of and purposes for developing explanations?	What are goals of and purposes for reviewing and critiquing?	What are goals of and purposes for justifying knowledge?	What are goals of and purposes for legitimizing ideas?
	Feelings/Affect	What feelings/affect are displayed during observation?	What feelings/affect are displayed as explanations are developed?	What feelings/affect are displayed during reviewing and critiquing?	What feelings/affect are displayed while justifying knowledge?	What feelings/affect are displayed when ideas get legitimized?

*Note. I illustrate these scientific practices here only as examples. The ethnographer examines scientific practices that emerge as important in the setting

If the card statements are written with the right balance of specificity and ambiguity, they provide great opportunities to elicit students' meanings and narratives of experience related to those norms and values. For example, the card "talk like scientists" is often very telling about access, what genres of talk are privileged from students' perspectives, and their perceptions of distinctions between their classroom science and "real" science. Sometimes students distinguish the kind of talk that is expected in their classroom from what they characterize as "formal" and "technical" and "big words" talk of "real" scientists. In these cases, students will sometimes say something like, "No, we're just supposed to talk like kids" and then go on to explain how "talking like kids" is different from "talking like scientists." Another time, we had a group of students explain, "Only certain students are expected to talk like scientists." Finally, in another classroom study, many students said they had to talk like scientists because they were encouraged to consistently use scientific vocabulary in their discussions. Each of these answers implies very different notions of what counts as science and who counts as a science person.

The second card statement task is to ask participants to choose the *three cards* that represent the most important practices and/or values for being a good science student. This part of the protocol allows us to later do analytic comparisons such as: How closely are students' perceptions of the important norms and values aligned with our perceptions? Do the students who get recognized by others as scientific have different notions of, or affiliation with, the important norms and values than those who do not get recognized as scientific? How much agreement is there about the most important norms and values across the group?

The first and second card statement tasks help identify aspects of the classroom culture; the third card statement task is focused more on individuals' valuations of the classroom's practices and values. In this phase of the protocol, we ask students to choose three cards that would be the most important for their ideal science class, which provides information about the alignment between their goals, values, talents, and interests with those promoted in their current classroom. In the next section, I provide more information about other ways our research team conceptualizes individual students' identity work.

3. Who Gets to Be Scientific?

As we began to get a better understanding of scientific practices important in each setting, we also examined a key issue related to equity–participants' strength of opportunity to become scientific (Gresalfi, et al., 2008). How accessible, compelling, believable, and achievable were these celebrated practices for a wide range of students? (Eisenhart & Finkel, 1998). At this point, analytic goals can focus on both patterned behaviour across the classroom and over time (cultural, group-level analysis) as well as individuals' identity work (the ways individuals take up, resist, and/or transform normative practices and meanings).

The following strategies (or codes) are particularly helpful in defining the accessibility of becoming scientific: Identify: (1) the nature of students' bids for

recognition (Gee, 2000–2001); (2) others' responses to students' bids for recognition; (3) instances of students holding the floor (for what reasons and with what opportunities); (4) instances of conflict. Recognition of self and by others is an important concept in identity research (Carlone & Johnson, 2007). I have also found that this concept (recognition) lends insight into the culture of science learning settings and, in particular, the normative science identity in a setting (e.g., "who counts" as being scientific). Students figure out fairly quickly the privileged ways of behaving scientifically and many seek to be recognized for instances when they perceive their behaviours align with those privileged by the classroom culture. We call these "bids for recognition" (Gee, 2000–2001).

Students' bids say something about what *they* think "counts" and/or what is important to them individually, providing information about the identity work students engage in to author themselves as a certain kind of science person in the classroom. We also examine the patterned ways students' bids are taken up, ignored, praised, or even admonished because that provides additional information about students' identity work and the cultural meaning of being scientific in the setting.

Our third strategy for identifying "who counts" is to examine instances of and opportunities for students *holding the floor*; that is, students speaking or acting for an extended period of time in ways that hold others' attention. Because traditional classroom participation patterns are dominated by the Initiation-Response-Evaluate (IRE) discourse pattern (Mehan, 1979), instances of students holding the floor are telling examples of "who counts" as being scientific and the nature of contributions that count as scientific in the setting. In addition, students' bids to hold the floor (or lack thereof) provide evidence about individual students' identity work. For example, we found a number of instances in the data in Mrs. Sparrow's class where the African American girls' bids to hold the floor for their scientific ideas got dismissed by their peers. At the beginning of the year, these girls made many bids to hold the floor, but by the end of the year, their bids became less and less frequent to invisible.

Interestingly, in Ms. Wolfe's class, two of the students most interested in, and motivated by, science outside of school had the most difficulty holding the floor. These two boys (Camillo and Adam), continually made bids to be recognized for the wealth of scientific knowledge trivia they gained from reading science books or watching science-related television shows. However, Ms. Wolfe actively tried to push the class, and these boys in particular, to question authoritative texts and tried to diminish the power of the "know-it-all" student in her classroom. Thus, she often curtailed Camillo's and Adam's attempts at long-winded explanations, while holding the quieter students accountable for holding the floor to discuss observations of and questions about a scientific investigation the whole class performed. Though students noted both Camillo and Adam as very "scientific" in end-of-year interviews, many of them also critiqued Camillo's and Adam's ways of being scientific (as too "technical" or too rigid).

A final helpful code to understand students' identity work, especially in light of their negotiations with the meanings of science student promoted in the settings,

was *conflict* (with peers, the teacher, and/or the classroom norms and practices). Instances of conflict brought to the fore the students' struggles and frustrations in ways that made clearer the discrepancies between the settings' celebrated identities and students' preferred and/or aspiring identities. For example, Camillo (the student mentioned above) was consistently frustrated during group work when his ideas were not taken up by the rest of the group. Camillo's bids to be recognized as the *most* knowledgeable science student were often thwarted because the classroom's normative scientific practices promoted a meaning of scientific knowledge as shared and collaborative. We found it helpful to evaluate moments of conflict to better understand students' identity work in the context of the promoted meanings of being scientific in the setting (Carlone, Webb, & Taylor, 2011).

STUDYING CLASSROOM CULTURE FOR INSIGHTS ABOUT INDIVIDUAL STUDENTS' IDENTITY WORK

When I shift the question from "Who are students becoming?" to first examine "Who are students obligated to be?" I understand aspects of students' identities that would be masked otherwise. In an explicit attempt to denaturalize the concept of "scientific competence," I assume, *a priori*, that all students can be capable of and interested in science, given robust opportunities to do so.

Take, for example, the case of Julio, a Mexican immigrant student whose school science participation we have studied for four years, from fourth to seventh grade science (Rockford & Carlone, 2011). If you walked into Julio's 6th and 7th grade (middle school) science class (in the same classroom, with the same teacher), you would most likely see him not talking, slouched back in his seat, his head down or propped up against his fist, gloomily doing nothing, then copying classmates' answers. In the 20 observations we conducted of Julio in 6th and 7th grades, he never volunteered any scientific answers, asked any questions, took any kind of leadership role in small groups, nor showed any overt interest in any scientific topics presented in class. One might conclude, from these identity performances over two years, that Julio was not interested in school science, did not have any desire to be recognized as being scientific, and/or struggled to understand scientific content.

If we flashback to Julio's scientific performances in 4th grade science, we see a completely different picture of Julio. His 4th grade teacher (Ms. Wolfe) and many of his peers considered him a top science student. Julio was excited about scientific investigation, played leadership roles in groups, and eagerly shared his ideas and participated in discussions. I remember one day when Ms. Wolfe asked students to solve a problem with electric circuits and switches with minimal direction from her. Most students struggled with the set-up for quite a while before eventually becoming frustrated, unable to solve the problem. Julio sat down, quietly set up the circuit within two minutes, and then set up another circuit with more batteries. He was the only student in the class to solve the problem that quickly and with that little fanfare. He loved to tinker and problem-solve, was willing to take risks in

science, and was humble about his accomplishments. Though he was not "scientific" in the "knows-a-lot-of-facts" kind of ways promoted in traditional school science, he was certainly scientific in ways recognized by his teacher, peers, my research team, and me.

Why do we see such radically different Julios over time? We studied 11 students from Ms. Wolfe's 4th-grade cohort across four years and, though they all had shifts in identity performances, none were quite as radical as Julio's. Thus, we cannot completely explain this shift with typical explanations of the "middle school gap" or an adolescent slump. My point here is that Julio's identity performances in middle school science mask the ways in which he could be scientific; the ways in which he *was* scientific in his 4th grade science class (tinkerer, problem solver, collaborative, and able to get recognized for understated, but productive, contributions). In Ms. Wolfe's classroom, it was unacceptable to be silent, non-participatory, boastful of individual accomplishments, and a "know-it-all." Students were held accountable to be good observers, problem-solvers, and collaborators, and share scientific ideas. In Mr. Campbell's class, the students who knew a lot of scientific facts (who were "answer keys"), had perfectly organized planners, answered questions quickly and often, and turned in beautifully appointed science projects done at home were lauded as the "smartest" science students (Carlone, et al., 2011b). This image of "smart science student" was inaccessible to and undesirable for Julio. In end-of-year interviews, he expressed his "ideal science class" in ways that emphasized science as a collaborative, exploratory endeavour. If we jumped right to questions about Julio's identity performances in middle school science without asking about who he was obligated to be, we miss critical aspects of Julio as a science person. It would be unwise to characterize Julio as "scientific" or "not" before attending to the classroom culture.

A FINAL WORD

Examining taken-for-granted practices and accompanying meanings of science person promoted is part of doing equity-minded ethnographies of personhood that make visible some of the mechanisms that maintain science as powerful, narrow, elite, and exclusive. Critical ethnographers acknowledge the importance of questioning one's own taken-for-granted assumptions; knowledge is always partial, enabled and constrained by our particular positions along the matrix of oppression (Hill-Collins, 2000; Johnson, Brown, Carlone, & Cuevas, 2011). Those who have been most oppressed by racist, masculinist, straight, Eurocentric norms are more likely to see taken-for-granted norms that reproduce inequity. Thus, questioning "what counts" is especially important for scholars in more privileged social positions because privilege gets reproduced through uncritical take-up and buy-in of dominant norms and practices. As a White scholar interested in studying identity in the service of equity, I have to keep learning this lesson to question my own taken-for-granted assumptions.

This is why an anthropological lens and methods is so beneficial to identity studies in science education. They challenge research that begins with *a priori*

meanings of what counts as "good" science education and good science student, forcing questions about the kinds of people produced in/by school science. Blindly accepting *one* way of doing science education is dangerous, especially because often ignored, historical, political, and sociocultural forces all too often work in support of the status quo. Similarly, blindly assuming *one* way of being scientific thwarts many smart, out-of-the-box, creative, individuals from pursuing science further, recognizing themselves as scientific, and from seeing themselves as potential science contributors and/or users of scientific knowledge. Classroom ethnographies of personhood, as described here, promote reflexivity and critical thinking, highlight the ways culture gets (re)produced, and allow us to see scientific potential in students that might be otherwise written off or characterized as non-scientific.

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3. MULTIPLE IDENTITIES AND THE SCIENCE SELF: HOW A YOUNG AFRICAN AMERICAN BOY POSITIONS HIMSELF IN MULTIPLE WORLDS

INTRODUCTION

Children make meaning of their lives by telling stories. Using the characters, plots, and settings embedded in the worlds that are familiar to them, they construct narratives about themselves, about who they are and who they want to become. When listening to the stories that young children tell about their lives, we hear what is important to them and may be surprised by the unexpected connections they make between real and imagined worlds, between worlds inside and outside of school, and with the world of science.

In this chapter, I explore the identities constructed by one young African American boy named Kenny[1] as he recounts his experiences of school and science. By telling stories, he weaves characters and themes that bridge fantasy and reality and home and school to construct multiple identities with which he positions himself in relationship to peers, family, school, and science, and integrates these identities into the science self he believes himself to be and hopes to become.

THEORETICAL FRAMEWORK

When asked to describe themselves, people recount the experiences, ideas, feelings, values, dreams, and so on that make up the self they perceive themselves to be, the self they think others perceive them to be, or the self they hope to become (Callero, 2003; Holstein & Gubrium, 2000). They narrate accounts (De Fina, 2009), told from their own point of view, that may explain, entertain, inform, invent, defend, confirm, or challenge (Chase, 2005). These narrations are usually informal accounts of the past, present, or future, fragmentary episodes strung together for the purpose of reflecting on their lives and communicating to others who the narrators believes themselves to be in the moment. They are stories that people tell and retell in an effort to form and re-form a meaningful self in the telling.

Furthermore, people tell many *different* stories about themselves. Each of their stories are populated by an array of actors or characters who take on specific roles, assert particular values, and locate themselves within particular "as if" worlds (Holland, Lachicotte, Skinner, & Cain, 1998). The stories or narratives people tell are the context in which they construct identities (Kane, 2012), accounts through

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which they make sense of themselves and are made sense of by others in relationship to particular people, places, events, material objects, and semiotic systems. In telling stories, people construct multiple identities by dialogically positioning themselves within storylines (Davies & Harré, 1990). Moreover, each story is told for a particular audience in order to make meaning of the self in a particular context for a specific purpose. Audience or listener interaction is an important part of the process (Josselson, 2011; Lee & Roth, 2004). By being present to hear and respond in word or gesture, to ask questions about or comment on, the listener co-constructs the story and the identity. In the telling, both the teller and the listener shape and are shaped by the stories.

Kenny's stories were told in school, a type of figured world that Holland and her colleagues (1998) describe as a "socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (p. 52). Figured worlds happen in historical time. In this chapter, the storytelling was physically situated within a school building, and socioculturally situated in the figured world of school, in which Kenny was a student in conversation with a teacher, a Black boy talking with a White woman, and a child being interviewed by an adult. Kenny's position relative to me in the social and cultural power structures of school and society necessarily influenced the manner in which he constructed his stories/identities. These structures also shaped the types of stories/identities he chose to construct in those moments.

Kenny situated himself in figured worlds that Holland and her colleagues (1998) describe as "as if" worlds, "contrived interpretations or imaginations that mediate behavior and so…inform participants' outlooks (p. 52). His science self was constructed in three "as if" worlds that were salient for him, namely those of a superhero, a Smallwood (his mother's maiden name), and a scientist. Kenny's "as if" worlds, and the identities he constructed within them, were influenced by the boundaries of those worlds that existed, at least in part, in his own mind. According to Holland and her colleagues, describing the self in an "as if" world is a way of dramatizing the self and imagining who we would like to become. Imagining possible selves can have positive cognitive and affective consequences for children (Ancil, Ishikawa, & Scott, 2008; Oyserman, Bybee, & Terry, 2006). As science educators and researchers, we know that there is a strong connection between social identification and content learning (Varelas, Martin, & Kane, 2011; Wortham, 2006). Therefore, we need to be concerned with the possible science selves children construct in their early years of schooling because these identities will support their continued interest in, and motivation for, learning science. One way to understand children's constructions of possible selves is to explore the science identities they construct within particular "as if" or figured worlds.

Listening to children's experiences of school and science offers us opportunities to hear their stories and, therefore, their experiences, from their own points of view. By focusing on children's voices within the narratives they tell us, we can attend to the content (the told) and the structure (the telling) of the narration (Josselson, 2011), as well as the person relating the account (the teller). Culturally

sensitive research approaches stress the importance of using alternative frameworks, including interviews, storytelling, family histories, narratives, biographies, and so on, that allow for the co-construction of multiple realities and experiences from the perspective of the teller (Tillman, 2002), especially when the teller is African American. Moreover, such approaches need to be mindful of "the *nature* and the *production* of knowledge" (Martin, 2009, p. 29, italics in original) about African American participants, particularly by White researchers, so as to disrupt the discourse of failure, risk, and deficit that so often accompanies studies of African American children in urban schools. The goal of this chapter is to listen to the first-person accounts of one African American child's experiences of school and science from his own unique perspective and with his own voice, and to explore the resources he uses to construct a science self.

METHOD

Participants and Setting

The data for this chapter were collected over the course of a year as part of a larger research project called the Integrated Science-Literacy Enactments (ISLE), a collaborative university-school research project that studied science teaching and learning in urban classrooms by developing and implementing extended curricular units that integrated science and literacy helping young children learn both scientific content and discourse genres[2] (Kane, 2012). This chapter is based on data collected in one of the six ISLE-project classrooms located in a high-poverty, urban elementary school with a 100% African American student body in a large US Midwestern city. There were ten focal students in the larger study. This chapter focuses on one focal student, Kenny.

Kenny was a student in Jennifer Hankes' third-grade class. He was chosen for this study because he represented a unique case (Onwuegbuzie & Leech, 2007; Teddlie & Yu, 2007). Kenny's interviews were the longest and most extensive of all the interviews in the class. He seemed relaxed and eager to talk about himself and science during our conversations, and initiated several unusual topics, including his connection of science with comic books and superheroes. Kenny had attended this school since the first grade and at the time of the study lived with both of his parents and an older brother.

The ISLE approach emphasized collaboratively-oriented, dialogically-organized instruction that encouraged children to draw, talk, share, write, think, and do science with their peers and teacher. The ISLE units fostered open-ended conversations in whole-class and small-group setting and encouraged theorizing and reasoning, explaining, meaning making, and questioning around science ideas (Kane, Hankes, Varelas, & Pappas, 2006; Varelas et al., 2008; Varelas, Kane, & Pappas, 2010). As a researcher, I was a participant observer in the classroom during each of 46 science lessons (62 class sessions of 45–60 minutes each) over the course of the school year. I was familiar to both the teacher and children, engaged in many conversations with children, and conducted all the interviews of focal students, including Kenny's.

Data Sources and Analytic Approaches

The data for this study came from three types of interviews that took place over the course of one year during the larger ISLE study. All interviews were audio or video taped and transcribed. The first type of interview was the "Being a Scientist" (BAS) in which students were asked to draw themselves being a scientist two times and discuss what they had drawn and how it showed them being a scientist. The BAS interviews were conduced three times, at the beginning, middle, and end of the school year also (see also Tucker-Raymond et al., this volume). The second type of interview was the journal conversation (JC), which occurred at the end of the year. In the JC, the student and researcher chose several pages from the student's science journal, which had been an important component in the ISLE project, that they thought showed the student at their best as a scientist. The students described the entries and discussed why they had chosen those entries. The last type of interview was the "studenting" (ST) interview in which the students were asked to describe themselves as students and as science students and to reflect on how they thought others (teacher and peers) thought of them and why.

The data were analysed using a constructivist interpretive approach, which is consistent with constructivist grounded theory and incorporates the voices of the participants, recognizes the mutual construction of meaning, and aims for an interpretive understanding of people's lives (Charmaz, 2006; Kane, 2009). Narrative inquiry, a type of constructivist interpretive approach, explores the stories people tell to reveal how they view and understand their lives (Josselson, 2011). In narrative research, the narratives are to be understood as influenced by the context in which they are co-constructed (Chase, 2005; Lee & Roth, 2004). In other words, the interviews in this study were not simply collected from a student by a researcher in a school. Rather, they were enacted in a particular high-poverty urban elementary school in the context of the ISLE research project by this researcher and Kenny, a particular student. The analysis emphasized content and its meaning and aimed to give voice to Kenny's unique perspective as a young African American male attending a high-poverty urban elementary school.

FINDINGS

When I began interviewing Kenny, I did not expect him to initiate topics and images, such as superheroes, so distinct from the science he had explored during his third-grade year. Nor did I expect those images to persist in such significant ways throughout our conversations. Nevertheless, the worlds of comic-book superheroes and his family (using his mother's maiden name, Smallwood) became important venues with which Kenny connected himself to the world of science. In the findings below, I demonstrate how imagination, responsibility, and caring were, for Kenny, identity markers or aspects of his self that endured across identities. By interweaving these identity markers across three "as if" worlds, Kenny integrated his rich inner life, his family experiences and expectations, and his love of science into a science self.

Kenny the Superhero

Drawing on his extensive knowledge of comic-book stories, his love of science, and both real and fictional characters, Kenny constructed a superhero narrative to imagine a possible self with which to define his future and position himself as a force for good in the world. Superheroes are ordinary people who, through some traumatic or unexpected event, have acquired superpowers that have transformed their ordinary bodies into superhuman bodies. The superheroes Kenny described were often scientists who used their scientific knowledge to develop their extraordinary powers. For example, Spider-Man used his knowledge of engineering to develop wrist-mounted barrels that allowed him to shoot the adhesive webbing he used to climb the sides of buildings (Lee & Ditko, 1962). For Kenny, scientific knowledge was a form of power that both afforded the superhero prestige because he or she could display their might, but also enabled the superhero to invent and solve problems that might help others. Kenny, who had considerable scientific knowledge in a variety of areas that he shared during the interviews, such as about dinosaurs and forest animals, considered his own knowledge a form of power, too. With knowledge, Kenny would "pass the grade and pass college" getting the education that would give him the opportunity to be whatever he wanted to be. Education would give him the power to choose his future in both his real and imagined worlds.

For Kenny, however, having power was not sufficient. Power must be used to help others in need, and to contribute to making the world a better place, or, in the parlance of the superheros, to rid the world of super-villains. Kenny believed, as did Spider-Man, that, "With great power there must also come—great responsibility!" (Lee & Ditko, 1962). Being a superhero meant being, like Spider-Man, a very intelligent, but lonely figure who acted alone, but always on the side of justice and right, to use one's extraordinary powers to care for those in need. Kenny saw himself as using his knowledge/power to be a "helper," and comic-book characters afforded him the opportunity to connect his rich imaginary life with his scientific knowledge to construct a superhero-helper identity. He read comic books, watched feature films based on comic-book characters, and had notebooks in which he wrote and drew his own comics. Kenny explained that imagining through play helped him think of ideas about which to write.

> Actually, I haven't finished with my storybooks or comic books yet. I'm thinking of adding new parts by playing with my toys…I think up something when I play with my toys [and then] I could write it down in my book…Sometimes when I don't have // when no one is outside, I just make up my own friends because…whenever no one wants to play with me and whenever my family isn't interested, I could just make up my own imagination // imaginary friend…I just think of it when I'm lonely [3].

For Kenny, imaginative play was a source of ideas for writing his own stories, and when he was alone or lonely, he used imagining as a way to connect with the world of brilliant scientist-heroes who were like him in that they, too, often acted alone and anonymously. Stan Lee, the famous Marvel comic-book writer and co-creator

of Spider-Man, inspired Kenny to write and draw his own comics. Kenny noted, "Comics are kind of cool to read because sometimes I could think of my own armies and my own heroes, like Stan Lee used his imagination for Marvel Comics and created X-Men, Spider-Man, Tarantula—which is the Black Spider-Man, Daredevils, [and] Electra."

Kenny first became interested in comic books at home. His parents and older brother were comic-book enthusiasts, too. "My dad is a Marvel comics fan…my mom is kind of an X-Men fan," and the first comic books Kenny read belonged to his older brother. Kenny's best friend and classmate, Lawrence, also shared his love of superheroes. Comic-book stories were a source of entertainment and companionship. When he was bored in school, Kenny imagined them. "Sometimes [in class] I just be quiet and think of things in my head…because when I imagine things it could entertain me without even talking to people and I could remember things." Kenny then described what he imaged in an enthusiastic and detailed accounting of numerous comic-book characters by publisher (Marvel or DC) along with their roles within their respective comic-book worlds. Kenny was particularly drawn to Peter Parker, the fictional character better known as Spider-Man. Peter Parker was a bookish high-school student who loved science, but had few friends. While on a fieldtrip to a science lab with his classmates, Peter was bit by a "super" spider. Later, Peter noticed that he had extraordinary powers resembling those of a spider, including the ability to spin webs and react quickly to danger. Peter used his superpowers to rescue others and help the police. Peter Parker represented what Kenny was and hoped to become, a smart, but lonely, student by day and a superhero-helper by night.

Like Peter Parker, who completed high school and college despite all he could do with his tremendous powers, education was important for Kenny and a means to become the helper-hero that he imagined himself to be. He explained,

> Sometimes, I <u>imagine</u> things that what I'm going to do in school…I imagine myself passing the grade and passing college so I can become anything I want…I want to become a helper. I could help blind people. I could help the police. I could help fire fighters get people out of houses like uh on Spider-Man um Peter Parker, he helped a little girl while he didn't even have his powers!...[I would like to be] a helper so that way people who's in trouble, I would help them like Spider-Man without his powers…on Spider-Man 2, he [saw] the fire in the house so he went in without any // without his costume because he had to wear his glasses…so um he could save the little girl who was about four or three years old and he's about // he's almost about 17 years old in high school…[I want to be a helper like him] only that I could help all types of people and train guide dogs when I get over my fear of animals…[I could] help the construction workers, be an engineer, be a painter. I would help a lot of people [like] deaf people. The only thing I need to know is sign language and um // people [who] are blind, I could just hold my arm so that way when I tell them to go, they could just run across and I have to tell them that there's cars ahead and cars on the side…I [could be] a helper so that way people who's in trouble, I could help them like Spider-Man did without his powers.

Drawing on the Spider-Man narrative, Kenny constructed a superhero identity that entailed becoming a "helper" in the world. Just as Spider-Man saved the little girl without using his powers, Kenny could save people without having superpowers, but by using his scientific knowledge. Kenny would take up the mantle of the superhero to care for people in need (i.e., the blind and deaf) and assist those who work to rescue others (i.e., police and fire fighters) and try to make the world a better place in which to live (i.e., construction workers, engineers, painters). In order to achieve this goal, Kenny would need to learn new things, like sign language and how to train guide dogs. Thus, Kenny would stay in school and focus on learning. Being alone or lonely was simply the price he had to pay for being a superhero. Kenny imagined a world in which superheros took responsibility for the world and cared about those in need. These aspects of Kenny's superhero identity are reflected in the other identities he constructed during our conversations, which I present below.

Kenny the Scientist

For Kenny, scientists were smart individuals who endeavoured to gain new scientific knowledge they could use to help others, preferably superheroes. Scientists had "a lot of brain in their head," which meant they had extensive scientific knowledge and the skills and determination to learn more by observing, experimenting, writing, drawing, and reading. They worked alone in laboratories or out in the field so they could "learn from [their experiences]…and teach themselves" about scientific ideas, such as chemistry, weather, evaporation, and dinosaurs. Kenny saw himself as a scientist because he had acquired a lot of scientific knowledge. Throughout our conversations, he became animated when talking about a variety of science topics. For example, he volunteered extensive information about dinosaurs, such as their names, habits, characteristics, theories about their demise, and their relationships to existing animals.

For Kenny, being a good scientist was about being a good thinker, using information to draw conclusions. "[In science class,] I'm good at thinking because sometimes I think when I read…I think about what she's [the teacher's] saying // what we're going to do in my head. So then sometimes I think about it // my prediction // in my head might be right…like when we did the dinosaurs and I knew <u>a lot</u> about them." As his teacher read aloud from non-fiction science texts, Kenny thought about what he knew and confirmed or disconfirmed it against what his teacher was reading and how he might use that information in the assignment she would give the class. Kenny knew that he had substantial scientific understandings, but he also knew that he did not always understand it correctly so he listened carefully. For Kenny, scientists were people who had extensive knowledge, but were always learning new ideas. Moreover, Kenny believed his teacher and peers thought of him as a knowledgeable scientist, too. He noted, "[My classmates and teacher] thought of me as a thinker…[because] I'm really good at working and really good at listening…they thought of me as a smart person because I knew <u>a lot</u> about dinosaurs."

Kenny also saw himself as a scientist when he engaged in scientific practices, such as observing, experimenting, reading, writing, and drawing, for the sake of learning and using that knowledge to help others. For Kenny, a scientist was always "doing something…and then they learn from it. Like if they try to make a chemical potion, and it doesn't <work>, they'll learn that they couldn't make it…even if they try more…[And by] observing what was outside…so they could see // so they could predict what's the weather going to be tomorrow like a weatherman does." Another way Kenny learned new ideas was by reading "because if someone reads, they can find out about [it]…because scientists have to learn new things." Kenny also acquired scientific knowledge by writing and drawing about his observations. "I would describe myself as a scientist because we found out all types of animals and different things…[and], when I observe, I write in my journal and draw a picture of what I saw." Kenny was doing science during hands-on explorations, in which he observed and experimented with live earthworms, observed and recorded the weather, and theorized about what was happening over time to the water in a graduated cylinder during the evaporation experiment.

Kenny connected his science identity with the world of superheroes by imagining a science lab in which he created chemical potions so he could help the comic-strip characters he had read about. In our first conversation, Kenny described himself as a scientist who worked in a lab raising venomous snakes, scorpions, and spiders that he would use to make potions to "make you strong [superhuman] and make you turn back to normal." He also had drawn rats, flies, and bees that he used as food for the venomous animals, and several types of beakers and flasks for storing chemicals. Kenny described the checklists with which he meticulously kept track of each animal, saying, "These [checklists] are to check to see if I made the snakes, the spiders, and the scorpions // to see if they are deadly or nice [and] to see if they ate their food." In a thought bubble in his drawing, he wrote, "I need to work on my chemicals." At the end of the year, Kenny again described scientists as people who "observe and try to make something…[such as] chemicals from the snake's // from the worm's skin // [and] from the gooey part [of the animal]." Kenny described his work in the lab this way:

> [Scientists] study, like they're studying on venom that they need to do. That's why I put in [the drawing] the chemicals that make people stronger, the venom…because some scientists work on just animals like snakes, scorpions, and spiders…so they can take um all the <food> out of their stingers so they won't sting [with] their poison. So if the scorpion eats the bee's blood, they [bees] won't sting it [scorpion]. It won't hurt, but it will give the scorpion more venom…Some scientists study on people that's dead, but they take the skin off and see and look at the bones and study [them]…So the snakes, the spiders, and the scorpions, they're there to make [people's] bodies more stronger.

As a scientist, Kenny was not only caring for the animals in his lab, but he was also using his scientific knowledge responsibly by supporting the work of superheroes.

Kenny the scientist imagined himself using animal venom to create chemicals that could turn ordinary people into superheroes and then back to normal again, in the same way Spider-Man had superhuman powers and was able to be normal, too. Kenny the scientist also studied human anatomy using cadavers to invent new types of animal venom that might work for people. He helped the police investigate murders by doing "things, like experiment with the history of things [forensics], other than reading, like if murder is committed and the cops need their help, they [scientists] will try to investigate with the cops." For Kenny, it was not enough to read and accumulate scientific ideas, scientists must also engage in the scientific practices that would put that knowledge to use to help others.

Kenny also connected his science identity with the world of comic books by drawing pictures of himself being a scientist using a comic-book genre. In one of his drawings, he described his experience of observing the weather on a hot day this way, "And here's me starting to smoke and melt because it was hot [in the sun]." Three lines representing steam rose up from his head, and the letters "ssssss" communicated the hissing of steam as he sizzled in the hot sun. In the drawing, he was holding a piece of paper on which he wrote, "Uh, oh," because he was about to melt. The sun, also a character in the drawing, was looking away because, as Kenny explained, "He's [sun] not paying attention…and so that's me that's already melted and still melting some more." Another thought bubble in the picture read, "I am an egg," which he explained this way, "[Because] you know, when you crack an egg then you make it scrambled [and] it spreads out like that? That's how I am…The sun is looking away [because] he just probably looking at other people and when he sees me, he just quickly turn around away from me because he's trying to go somewhere else in the world. But no matter how far he is, he's still gonna be too hot." Kenny's image of an egg may be a reference to the idiom, "It's so hot you could fry an egg on the sidewalk." Using a comic-book genre, Kenny communicated accurate scientific ideas about the intensity of the sun's heat, and the notion that, even though the sun appears to be shining "over there" (or in the direction that the sun was looking in the drawing), it would still radiate heat "over here" (where Kenny was in the drawing) because the sun's energy radiates in every direction at once.

Kenny imagined a smart, responsible, and solitary scientist identity with which he worked in a lab to help superheroes and police officers make the world a better place. He connected his love of drawing comic-book characters with his science identity to communicate scientific understandings. For Kenny, being imaginative and responsible was as much a part of being a scientist as having scientific knowledge and engaging in scientific practices. In his Smallwood identity also, Kenny hints at the source of the responsible and imaginative identity markers.

Kenny the Smallwood

For Kenny, being a Smallwood, the son of his mother, Paulina Smallwood, meant belonging to a family with whom he had fun, a family that cared about him, valued education, and supported his efforts to succeed. Kenny's family both had high

expectations and offered him an example he could emulate. Kenny's Smallwood identity influenced not only how well he succeeded in school and how he acted in school, but also what he thought about learning and how he approached difficult tasks, such as the state achievement tests. Though Kenny lived with both of his parents and an older brother, it was his mother to whom he referred most often in our conversations. This is the reason why I refer to this identity using his mother's maiden name even though Smallwood was not Kenny's surname.

Kenny's mother was a significant role model for him. Not only had she attended the same school he did, but she also had been a successful student, and her success in his school helped him imagine his own success because he was her son. He explained, "My mom came to this school and she passed…actually, she skipped [a grade] because she was smart…[so] when the [state achievement] test came, it was gonna // it wasn't gonna really be a challenge because my mom came to this school and she passed." In fact, during the year of the study, she was studying to become a teacher. In addition, she had given him advice about how to think about the tasks school would require of him. Kenny believed that his mother knew he was smart, so school should not be all that difficult. "My mom was saying that // was telling me that, 'How is it [the state achievement test] hard? All you have to do is just go back in the story and fill in the circles,' and I just tried my best." When he did try his best, his parents rewarded Kenny and his brother for their excellent report-card grades by taking them to the store or online to buy a video game, new clothes, a toy, notebooks for writing, or comic books.

Others at his school confirmed Kenny's perception of his mother, too. Kenny's physical education teacher, Mr. Johnson, had also been Kenny's mother's teacher. Kenny perceived Mr. Johnson as expecting him to live up to his mother's example of being well behaved and hardworking, but Kenny also perceived Mr. Johnson as believing Kenny would succeed because he was a Smallwood. Kenny explained, "I'm a Smallwood…I'm Paulina Smallwood's son…She used to go to this school…and Mr. Johnson knows that when my mom was here she acted go:::od and now that I'm here, I act like the same like her…[and Mr. Johnson], he knows that I'm a Smallwood, he knows that // he remembers that when I was // when my mom // he thinks of me like as my mom because she was go:::od." For Kenny, being the son of Paulina Smallwood was both a privilege and a responsibility. While Kenny knew he was expected to act just as "good" as his mother had when she was a student in Mr. Johnson's class, Kenny also knew that Mr. Johnson perceived him as a well-behaved student because he was Paulina Smallwood's son.

For Kenny, another important part of being a Smallwood was being attentive and focused on learning while he was at school. "I know how to act mature…and when I got something wrong, I learn from that mistake and never try it again." For Kenny, being a "mature" student meant listening to the teacher, focusing on schoolwork, and being quiet in class. Kenny explained,

> "I think I'm good at listening, being focused, [and] being quiet because a lot of times I don't talk a lot because sometimes I just be quiet and think of things in my head…I acted good because whenever I'm at school, I cannot act bad...[Being good is] when you're your thinking about things and you

> never talk or never get kicked out of the <group>…I just acted like my mouth is stapled together…I am good at working and really good at listening so sometimes when I think // because sometimes when I think that I am not supposed to do something, I just don't do it and whenever Ms. Hankes um tells me something, I just follow the directions."

For Kenny, being smart and being well behaved seemed to go hand-in-hand. One way he was able to stay focused was to work by himself "because when I work alone it helps me get focused and work," or with others who were equally focused. Ultimately, however, being well behaved was not an end in itself, but a means to his long-term goal of graduating from high school and college and achieving his life aims. School was the place where Kenny could "learn new ways to do things and learn new things so we can do it in the next grade and get to college and get an education…I know if I don't get good grades a lot of times I won't pass on to any other grade…[so] I feel happy in school because she [the teacher] could teach me new ways // new things that I could do in fourth grade."

For Kenny, being a Smallwood was like wearing Spider-Man's costume. Not only did it set him apart from others, but it also gave him the power to overcome any academic or social obstacles that he might encounter in school. Kenny's mother mediated his relationships to school and learning by focusing him on what was most important and giving him strategies with which he could succeed. Her influence was much stronger—at least in the third grade—than the peer pressure to misbehave or lose his focus on learning. For Kenny, being a Smallwood meant being responsible for living up to his mother's legacy of academic success and good behavior. Being a Smallwood was also an asset because, with her name, came the expectation that he would succeed and the privilege of being treated as if he would.

DISCUSSION

This chapter explores how Kenny, a third-grade African American boy who attended a high-poverty urban school, constructed a way of seeing himself in relationship to science. By drawing from the three "as if" worlds of superheroes, Smallwoods, and scientists, and interweaving imagination, caring, and responsibility across these worlds, Kenny constructed a sense of self that spanned in-school and out-of-school people, events, ideas, values, and experiences.

Three enduring markers of identity emerged as Kenny constructed a science self: imagination, caring, and responsibility. I do not suggest that these are Kenny's only identity markers; I suggest that they were the most salient markers for him at the time of the study. The diagram (see Figure 1) shows the relationships between Kenny, his identities, and his identity markers. Kenny used the characters, settings, and images from three worlds: superheros, Smallwoods, and scientists, to position himself within those worlds. Three enduring aspects of his self were evident across identities and marked him as a certain kind of superhero, Smallwood, and scientist.

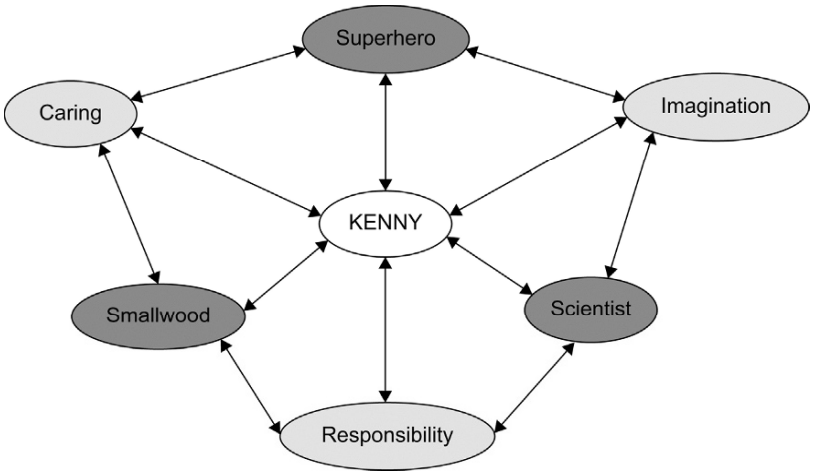

Figure 1. Kenny's identities and identity markers.

Kenny's three identity markers were not equally distributed across worlds, being more evident in some than in others. Imagination was central to his superhero and scientist identities, and allowed him to participate in the world of comic-book superheroes by imagining being a helper who would assist those in need. Imagining with his toys gave him access to characters and storylines that he could write about in his notebooks. And, imagining himself being a scientist enabled him to participate in the world of superheroes by inventing chemical potions that would assist their efforts to rid society of super-villains. Holland and her colleagues (1998) have noted that the images people use to construct "as if" worlds are not simply abstractions, but social realities for the person constructing the narrative and represent very real perceptions, for example, of the superhero world in which good and evil co-exist. Moreover, imagination was also a companion for Kenny when he was alone or lonely, a creative tool used by important people he could emulate, such as Stan Lee, and a vehicle for constructing possible selves to which he could aspire. Kenny's imagination was present in his thinking about scientific ideas, too, the thinking at which he was so competent. As his teacher read non-fiction science books to the class, Kenny was imagining ideas, making connections, and wondering how his ideas might compare to those shared in the book.

For Kenny, being a responsible person was central to being a scientist and a Smallwood. Scientists were intelligent people who were responsible for teaching themselves and continually learning new ideas. Scientists learn because they love to learn, and certainly Kenny loved sharing his extensive scientific knowledge. However, scientists learn not just for the sake of accumulating knowledge, but also to use their knowledge to help others. In other words, scientists have a responsibility to act for the good of others. As a Smallwood, the son of Paulina Smallwood, Kenny was responsible for living up to the family name. Although

Kenny's surname was not Smallwood, it was his mother's example and determination that led him to identify so closely with it. She provided an example of success in school and life. She had attended the same school he did, and had prospered. She inspired him to keep learning by being a student herself. She gave him goals to strive for in the prizes that rewarded his high achievement, encouraged him to think about how his present schoolwork would help him achieve future success in high school and college, and gave him a way to think of the stressful standardized tests as manageable. After all, how hard could it be? All he had to do was look back at the story and fill in the circles. Kenny clearly recognized the value of knowing that he was a member of a family that valued education, supported his academic achievements, and challenged him to succeed. Furthermore, he embraced the notion of being responsible for something greater than himself, whether it was using his scientific knowledge to improve society or to live up to his mother's legacy as he had constructed it in his own mind.

For Kenny, it was important to care about others, and undoubtedly he felt cared for by his family. Kenny's family knew how to have fun together. In addition to sharing the worlds of comic-book heroes, they negotiated the ordinary tasks of family life in fun ways. For example, Kenny laughed as he told me about the bets he made with his mother that his father would wash the family's clothes. If Kenny won, he would get a reward at the store. If his mother won, Kenny and his brother would have to wash the dishes. Perhaps this was Paulina Smallwood's way of including her children in the responsibilities of family life or her way of encouraging their father to help out around the house. For Kenny, who claimed he won the bet "about two or three times," it was a way to be part of a family. While being a Smallwood meant having responsibilities, it also meant being cared for and having the opportunity to care for others. In much the same way that superheroes did not have superpowers simply for themselves, but were responsible for using those powers to care for others, Kenny would use his power to help others. There are two types of comic book characters: heroes and villains. For Kenny, the choice was obvious to side with the heroes by expressing care for others.

CONCLUSION

This study began as a series of conversations about being a student and a scientist. With Kenny, those conversations took unexpected turns to engage with superheros who battled evil villains and scientists who created chemical potions with scorpion venom. The worlds of superheroes and Smallwoods, which at first glance seemed unconnected to science, were interwoven with imagination, responsibility, and caring into a science self that has implications for Kenny's possible future self.

What Kenny's case demonstrates is that children's science identities are not singular constructs composed in the midst of a particular set of discourse practices. Rather as children construct science identities, they weave complex and rich relationships between distinct parts of their lives in and out of school (Banks et al., 2007). They draw from wider perspectives and experiences beyond the science curriculum they experience in school. They use ideas as distinct as comic-book

heroes to connect both what they have experienced and what they perceive as important to shape ways in which they identify with science and construct science selves.

As educators and researchers, we would not know about the connections children are making with school and science unless we engaged them in conversation. In-depth investigations are needed, particularly with African American children, and especially boys, who attend high-poverty urban schools, precisely because they are so often portrayed as disengaged, disaffected, resistant to learning, and unprepared to engage in science learning. First-hand accounts of their lives and experiences can uncover the rich and complex ways in which African American children make connections with school and science as well as the resources they bring to school to do so. Further research is needed to explore how African American children in urban schools construct identities in school and science. Exploring science identity constructions with young children is especially important because science education in the early years matters (National Research Council, 2011). Moreover, children will draw on the science identities that they develop as young students when they make the critical shifts to middle and high school science. We know that these shifts represent a significant moment in which many children lose interest in science learning. We also know that there is a strong connection between social identification and content learning (Varelas, Martin, & Kane, 2011; Wortham, 2006). Further research is needed to support teachers' efforts to promote the development of meaningful and positive school and science identities, and to help educators develop curricular and instructional approaches that draw on children's life experiences and engage them in meaningful science inquiry that helps them imagine their possible selves in relationship to science.

APPENDIX: KEY TO SYMBOLS USED IN TRANSCRIPTS

//	Repetitions or false starts or abandoned language replaced by new language structures
< >	Uncertain words
Underscore	Emphasis
:::	Prolonged vowel sound
[ ]	Identifies what is being referred to or gestured and other nonverbal contextual information
…	Part of a transcript has been omitted

NOTES

[1] All names are pseudonyms.

[2] This material is based on work supported by the US National Science Foundation under grant number REC-0411593. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

[3] See Appendix for key to symbols used in transcripts.

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4. KAY'S COAT OF MANY COLORS: OUT-OF-SCHOOL FIGURED WORLDS AND URBAN GIRLS' ENGAGEMENT WITH SCIENCE

INTRODUCTION

Kay's face lit up when she realized that urban heat islands (UHI) were not actual bodies of land surrounded by water somewhere in the middle of a city. When she grasped the notion of "island" as a metaphor, she understood why she had never actually "seen" one, despite having lived all her life and having received all her schooling in urban settings. As she later explained, "An urban island is an island, well not really an island, but it's a place where there is a lot of people so it makes it really hot."

Later, when Kay interviewed people in her city about their knowledge on UHIs (as part of a community ethnography), few could give Kay an answer. For instance, when a hot and sweaty groundskeeper agreed to be interviewed but struggled to answer her question, Kay took it upon herself to restate her question in a way that might connect to his experiences.

Kay: Well, where would you want to go if you were really hot?
Groundskeeper: Uhm.

She then followed up with more detailed responses in which she shared her own ideas, keeping in mind the man she was interviewing and his context. As she pointed to the area grounds that the man was in charge of tending, she said:

Kay: There are trees and there are grass and it helps the heat island effect because, it makes it more shady… and instead of everybody being hot and instead of people being, people not like, being, not to like being downtown, they can kind of enjoy it if they just go in the shade.

Somewhere along the way–at school, at home, watching TV–Kay, who was then 10 years old, had constructed an idea of what an island meant, an idea that was challenged when it was re-signified in an out-of-school setting (i.e., the after-school science club that she has attended for several years). Later, when she took on the role of educating others, she recognized that those pedestrians could have also shared her initial confusion and addressed the metaphor in her dialogues. While Kay admittedly had one of the weaker understandings of UHIs of all of the

M. Varelas (Ed.), Identity Construction and Science Education Research: Learning, Teaching, and Being in Multiple Contexts, 43–60.

students in the program, we believe her actions reveal her efforts to make science accessible to others.

In the same way that this event suggests, most of the interviews, videos, and artifacts that Kay has produced over the past four years capture the words and doings of a sensitive and intelligent girl who has purposefully used her science and technology learnings to transform her own life and her community. Thus, as we delved into the data, we struggled to understand why her school report cards and her participation in school science did not embody the importance of her accomplishments. "It's like that coat in Dolly Parton's song," one of us said, "It's stitched with love and the girl feels proud to take it to school, but once she gets there, she does not understand why others fail to see its magic." The fact that Kay has been successful in out-of-school settings but is a mediocre student who merely "deals with" school science hints at the possibility that Kay is able to construct a strong and positive science identity by leveraging and making meaning of non-traditional resources.

In this paper, we share Kay's narratives to unpack how she crafts an identity with and in science. We focus on the ways in which she understands, describes, and leverages the complex web of resources her family and out-of-school figured worlds provide her in her science journey. We are particularly interested in Kay's story because, as we highlight in our conceptual framework, the resources that are most powerful in Kay's recounting of her family figured worlds run counter to what the research literature indicates is powerful in terms of family support for girls in science. We will use Dolly Parton's song "Coat of Many Colors" (1971) to convey the importance of her narrative.

BACKGROUND: "FRAMING" AFRICAN AMERICAN GIRLS IN SCIENCE

Girls' Science Trajectories

Despite the increasing success of African American girls in national achievement measures, we are troubled by the continuing trends relative to their identification with, and participation in, science, which receive scant notice. Despite relative equal achievement in science education, African American girls tend to not identify with science (Brickhouse & Potter, 2001; Carlone, 2004), and do not persist in science (National Science Board, 2004; National Science Foundation, Division of Science Resources Statistics, 2004). The problem grows the further the girls progress along their potential science trajectory. In 2007, the National Research Council's Committee on the Guide to Recruiting and Advancing Women Scientists and Engineers in Academia reported that women in general, but especially African American and Latina women who are interested in science and engineering careers, are lost at *every educational transition*.

In recent years, there has been a more nuanced approach to understanding girls and the science pipeline, as indicated in the aforementioned report. Earlier work in this domain examined whether girls were "in" or "out" of the pipeline. However, recent work has called attention to the fact that there are, in fact, many branches to

the pipeline that operate simultaneously, including achievement, access, attitudes, and activity (Hanson, 1996), and that movement through and in and out of this pipeline looks different for girls from different racial and ethnic groups (Gilmartin, et al., 2006). We concur with the recent work of Aschbacher and colleagues who have further expanded the idea of the pipelines to include not only the "curricular and extracurricular behaviors, attitudes, and choices" that prepare students for a future in the sciences, but also "a broader range of science, engineering, medicine, and related careers" in order to be inclusive of a more diverse student population and the pathways they take towards a variety of career goals (Aschbacher, et al., 2008, p. 4).

Barriers, Support Mechanisms, and Family Influence

The past fifteen years have also revealed insight into the barriers girls face in their quest to express interest in and participate in science-related trajectories despite improvements in achievement (American Association of University Women Educational Foundation, 1999; Brotman & Moore, 2008). These barriers are complex and dynamic. The social, structural, and psychological dimensions held in place by schools and society work together differently for any one girl at any one time, making it difficult for them, their families and the education community to identify and make concrete and lasting changes in support of girls in science. For example, barriers include societal attitudes that portray science as masculine, curricular and pedagogical approaches that value only a limited range of identities and experiences, and a continued lack of equity-minded curricula and professional development tools for teachers (Brickhouse & Potter, 2001). Girls living in low-income urban communities continue to face additional barriers, including limited access to rigorous and high-level science courses, science equipment, appropriate role models, and certified, qualified teachers (Oakes, 2000).

One primary mechanism of support identified in the literature has been that of the family. Parental influence has long been considered an important factor in children's success in school (Berger, 1995). It has been documented in the research literature for several decades that families matter in student success and interest in science learning and careers (Eccles, 2005; Frome & Eccles, 1998; Gilmartin, et al., 2006; Jodl, et al., 2003). Numerous studies have revealed how the attitudes of parents and other family members impact students' career goals and aspirations (Jodl, et al., 2001), and that girls' perceptions of their parents' support to pursue science impacts their career aspirations (Gilmartin, et al., 2007).

Some studies have specifically sought to unpack how families' influences take shape, especially for girls from non-dominant backgrounds. Not only do parental views on career expectations correlate with student aspirations; these effects can be seen fairly early (Eccles, 2005). Noteworthy are those studies that show that stereotypical views of science careers and of gender roles negatively impact girls, and correlate with lower enrolments in higher level math and science classes, diminished views of abilities to do science or math, and lack of persistence in science trajectories (Eccles, 2005; Gilmartin, et al., 2007). Other influential family

factors include parental participation in school science (Dodd & Konzal, 2000), parental beliefs about how they are to help their children and parental efficacy towards their children's schooling (Hoover-Dempsey, Walker, & Sandler, 2005). For example, some studies indicate that girls' parents are more likely than boys' parents to believe that science is difficult (Tenenbaum & Leaper, 2003). Additionally, according to U.S. Department of Education National Center for Education Statistics (2000), studies indicate that parental educational attainment and occupations provide youth with cultural and economic capital. Gilmartin and colleagues (2006) further remind us that "[c]ompared with White and Asian/Asian American students, Black/African American and Latino/a students are more likely to exit the science pipeline because of barriers like familial obligation and financial hardship" (p. 181).

The trends regarding parental influence on their children's–and especially their daughters'–science aspirations noted in the previous section have been both clear and strong over the past three decades. Indeed, studies of familial influence have declined in the last decade because these trends are so well documented. However, we note, that with the exception of the Gilmartin, et al.'s (2006) study noted above, no studies have sought to link girls' identity development with the family figured worlds. What is more*, few of these studies unpack the actual mechanisms of support, grounded in everyday practice, beyond the list of factors that impact girls' development in science trajectories*.

In this paper we highlight the story of one girl, Kay, because her narrative challenges many of the assumptions embedded in the previously discussed literature regarding barriers and supports that families offer to girls in their movement along science trajectories.

CONCEPTUAL FRAMING: RE-FRAMING FAMILY FIGURED WORLDS AND GIRLS' SCIENCE IDENTITY WORK

Drawing strongly upon anti-deficit orientations for understanding how African American girls' author possible selves in science, we build an argument for why one of the girls in our study is interested in science, and the familial-based resources and contexts which support her in developing these interests in ways that matter to her. To do so, we draw on counternarratives, or narratives that make explicit and central the knowledge and experiences of those on the margins.

Counter-storytelling

Scholars from critical race theory have argued that it is important to move outside dominant discourses to understand and act upon the experiences of youth whose experiences have been marginalized. They argue for ways to understand how issues of race and ethnicity intersect with class and gender to frame not only the experiences individuals have but also how these experiences are understood and taken up by others (Ladson Billings & Tate, 1995). For example, we need to find ways to uncover how institutional stories–like those about school achievement,

and who can do science or mathematics–are not neutral or objective. Further, they argue, we need to create new venues for allowing the experiential knowledge of students from marginalized positions to narrate new ways of understanding the challenges and possibilities of urban education (Solorzano & Yasso, 2001).

Counter-storytelling has been defined by Delgado (1995) as the telling of stories of, and by, people whose experiences are not often told, such as low-income African American and Latino youth in urban schools. Counter-storytelling has been utilized within the critical race theory tradition as a tool for accomplishing two related goals. First, as a tool for exposing, analyzing, and challenging the stories of those in power and which are naturally a part of dominant discourse (Delgado, 1995). Second, counter-storytelling has been used as a tool to build community among those at the margins and to challenge the perceived wisdom of those at society's center. Counterstories do this by opening up new windows into the reality of those on the margins allowing new and different possibilities to be showcased, and by combining elements of the story and the current reality, thus constructing another world that is richer than either story or reality alone. Counterstories work against setting up their own master narrative by asking us to "develop multiple and often conflicting models of understanding social and cultural identities in ways that support our ability to hold complexity and broaden our perspective of the possible" (Solorzano & Yasso, 2001, p. 475).

Testimonio

Testimonio has been known as narrative text within the Latin American resistance literature (Harlow, 1987). Beverly (2004) refers to testimonio as story that is told in the "first person" by a "narrator" who is a "witness to the accounts he she recounts, and whose unit of narration is usually a "life or a significant life experience" (p. 30). He argues that testimonio is powerful and persuasive as a form of resistance literature because it is both "protean" and "demotic."

Historically testimonios, as "edited oral narratives" (Carey-Webb, 2001, p. 133), are written about and for people who are not able to write about their own experiences. While the ability to write one's own experience has been historically related to written literacy, recent work on testimonio calls into question how issues of power and language shape access to discourse communities and how the "ability to write" is just as much about who one writes for as it is the process of actually writing. Therefore, testimonio has gained traction as a mode of discourse that allows the experiences of those outside academia to have a 'real' presence within that discourse community.

The experiences of those on the margins continue to be marginalized in academic circles because the discourse and practice of the academy exclude the worldviews of those outside its boundaries. When stories of those outside the boundaries are brought into the discourse, the deeper meaning of the stories is "lost in translation." Furthermore, testimonios call attention to *a broader pattern of cultural experience*, despite their location in the story of an individual. As Carey-Webb explains,

> [Testimonios] differ from traditional oral histories as they emphasize the experience of the group rather than the perspective of the individual…Acts of memory situated in time, testimonials help us to learn about history, revealing connections between personal experience and collective reality. (p. 133)

Counternarratives: Creating Spaces for Impossible Knowledges & Identity Work

Counterstory and testimonio call attention to the experiences of the marginalized, and position those stories as powerful tools for problematizing master narratives. The term "counter" is used to call into perspective dominant or normalizing "master narratives", or "scripts that specify how social processes are carried out" (Stanley, 2007). Some have referred to these counternarratives as "impossible knowledges."

> Testimonio has the potential to create space for other impossible knowledges that are underrepresented or invisible within conventional academic discourses (Haig-Brown, 2003, p. 416).

We like the term "impossible knowledges" because it reminds us just how much these narratives contain information and understandings that are "beyond our grasp *because of the limits of our language and our lived experience*" (Haig-Brown, p. 416, emphasis ours). Impossible knowledges also contain "frames" for challenging stories of those in power by repudiating stereotypes, giving witness, and uncovering assumptions and normative patters.

Impossible knowledges also call attention to the link between narrative production and identity work. Take, for example, the stories of the Native American women environmental justice advocates (Prindeville & Bretting, 1998). These Native justice workers viewed their community work in terms of their "life purpose, inseparable from identity" (p. 48). They sought to make their own experiences matter by working with others on issues central to the survival of their communities (e.g., environmental degradation, work safety, and pollution); they created collaborations with local media to have their stories aired, to get position statements made public, and to initiate and hold public hearings. Their stories show that part of counter knowledge is not only documenting stories, but also creating pathways or venues for having such stories heard by multiple audiences.

We believe that the relationship between counternarratives and identity work is central to unpacking the patterns of interest and participation in science among school-aged girls as they traverse the different worlds that make up their lives. Counternarratives provide a view of the lives that girls live and to the women they want to become. They also provide insight into the resources that girls might leverage in achieving these goals. They also show us how girls challenge historical, institutional and cultural narratives of what it means to become a woman in science.

How girls craft an interest in science through participation in their out-of-school figured worlds, such as a cooking club, or family science at the local garden can

impact when and how girls seek to pursue participation in their school classroom. Yet, the ways in which girls take up these different forms of participation are deeply tied to culture and context. How girls draw upon their roles as babysitters or soccer players in the home or community, as actresses or group leaders among their peers, can also shape how they choose to pursue science or not. Likewise, how teachers recognize and understand these experiences and their potential connections to science also play a role in whether and how girls choose to pursue science or not. Furthermore, embedded in these stories are likely critiques of normative practices in science, and insight into how these practices constrain and marginalize those for whom the discourses and practices of science do not reflect their own cultural repertoires.

These worlds that exist outside of school science provide girls with a wide variety of resources and positionings that they can and do draw upon to author possible selves in science. We believe investigation into how girls perform this authorship in the ways that they leverage the experiences, resources, and positions of different figured worlds will help us with the individual level patterns that we know are missing from the research literature on how and why girls develop interest and participate in science over time.

KAY'S COAT OF MANY COLORS–A METAPHOR FOR HER POSSIBLE LIFE IN SCIENCE

Inspired in events from her childhood, Dolly Parton's "Coat of Many Colors" (1971) tells the story of a coat sown by her mother out of an assortment of rags and the inability of others to see the love that was stitched into the garment. When the girl proudly wears the coat to school–for her mother has kissed it with hopes of "good luck and happiness"–the "others" (primarily at school) fail to see its richness; contrarily, they read it as evidence of her family's poverty. The last stanza explains how she understands that her family "had no money" but she felt ultimately "rich" because she recognizes that love, rather than poverty, is what transforms the rags into a coat.

We believe that Parton's song is an artistic exemplification of a counternarrative and that the coat in the lyrics serves as a sensible metaphor to explain our findings. In the song, the narrative sown into the coat (i.e. the biblical tale, the kisses and blessings) is evident for Parton and her family; nevertheless, "because of the limits of […] language and […] lived experience" (Haig-Brown, p. 416), it embodies information and understandings that are beyond the grasp of those at school, thus, constituting a form of "impossible knowledge." Kay's performances in science might also be incomprehensible if read from the perspective of dominant discourses. Furthermore, the song provides a family referent (i.e., the mother) that helps us in addressing family influence in Kay's science identity work. Kay, like Dolly, takes to school a piece of identity created at home (and at after school club) and then engages in a process of meaning making across these worlds. Thus, we find Parton's song useful to present Kay's counter-storytelling and recognize "multiple and often conflicting models of understanding social and cultural

identities in ways that support our ability to hold complexity and broaden our perspective of the possible" (Solorzano & Yasso, 2001, p. 475).

Therefore, in order to see the love stitched into Kay's "science identity coat"–rather than seeing her race and socioeconomic status as the poverty of the rags–we have threaded her words and work with the lyrics of the song, presenting them along three narratives: Narratives of navigation, protection, and endurance. After sketching her portrait in "Getting to know Kay," we present her "Narrative of Navigation." Making meaning from her mother's and sister's trajectories in her family-figured world and drawing resources from other out-of-school figured worlds, Kay (like the girl in Parton's song) is compelled to negotiate and build upon those resources to navigate her way into becoming a doctor. In the same way that Parton's mother stitched the coat "way down in the fall" to shelter her daughter from the harsh weather, Kay's "Narrative of Protection" portray the way in which she creates ways of safeguarding herself and her community from master-narratives that fail to acknowledge her ways of conceiving and doing science. Nevertheless, Kay's "protection" is not exclusively defensive; she also challenges and transforms hegemonic precepts of what scientific is. Thus, in the final section we present her "Narrative of Endurance", as science identity work that allows her to bear–while transforming–the challenges within her community **and** within marginalizing science discourses. Overall, like Parton's coat, Kay's narratives tell us of the love that was sewn in every stitch of her journey and how she has transformed seemingly disparate "rags" into a purposeful and beautiful coat.

Getting to know Kay[1]

We have known Kay since the summer of 2007–the summer before 5th grade when she joined the Green Club (GC) at her local neighborhood community center. Initially, she joined because her friend, Cathy, invited her; later in the year, she also remarked, "I JOINED Green Club work because it is a very responsible group of people and it is very inportant [sic]" (Green Club Survey, Feb. 2008). Even though the first time she remembered personally meeting science professionals was at the afterschool program, Kay (like many other children in the program) already had elements and symbols that she had put together to create a version of what science meant and about what a possible life in science might look like.

Kay is now about to enter 9th grade, and her movement through middle school has not been an easy one. She attends her city's K-8 magnet school for the performing arts. She opted into this partly because it was just down the street from her grandmother's house but also because she loves the arts, especially singing and dancing. When we first met Kay at the club in 2007, the club director quickly pointed out Kay's talent in writing–she had recently won a writing contest for 4th graders at her school. In the same breath, however, she worried for Kay's future, noting the difficulties her family faced financially and otherwise, and their impact on Kay's school attendance. Indeed, these two strands of Kay's life–a desire and effort on her part to make the best of school and to achieve, and an on-going

familial struggle for daily survival–have been present throughout these past four years.

Kay views herself as smart and fun loving, attributes that are not incompatible with her steady interest in science. Ever since we have known Kay she has wanted to be a doctor–a pediatrician or a brain surgeon–or, as she states on the webpage she authored at GC in 5th grade, "a nice career as a doctor." Through these years, her interest in science has been consistent, both in her descriptions of her desired career and in her indication that "science is fun." While at times she states that she does not care what people think about her ("*If your friends are not real, they think you a geek, but if they are they will be OK with it. Scientists are really smart, so it's ok to be scientific in front of your friends.*"), she, like most girls her age, still worries about others' perceptions ("*I really hate when people talk about me but I don't care because I am smart enough to know that it isn't true*.").

Kay's performance in school and talk about enjoyment of school has been somewhat erratic. Despite her love of science and her desire to be a doctor, she feels she has to "deal with" school science, rather than fully engage in it and enjoy it. While she views herself as smart and an A student, her grades do not always reflect that. She maintained As and Bs in 5th and 6th grade; however, 7th grade was a difficult year grade-wise, with a fairly consistent low C performance. Kay is defensive of these grades, noting that, "they don't let you make up things when you miss school" and saying that "when I'm there, I do good." Kay's absences appear far beyond her control, given the life responsibilities she assumed with the birth of her little sister, and the shifting "home-base" as her family experienced fairly dramatic economic upheaval.

Kay has stated that the toughest barrier to her desired future as a doctor is economic. Thus, in the same way that her grades prevented her from participating in the dance team (school rules), she recognizes that her low grades may be a hindrance to her "only hope" of getting a scholarship. However, Kay has sought other ways to make up for her grades, particularly by finding opportunities in after school clubs like GC. There, she has learned much of the computer skills and science that, she notes, will help her as a doctor. Most importantly, she expresses that unlike science at school, at GC you don't get "kick[ed] out" if you fail to attend the sessions; instead, "they catch you up on what they've done." This flexibility and encouragement has allowed for a feeling of belonging to the club, to the extent that she considers she is "technically working there" and hopes to continue doing so until she has to "retire." Indeed, as we highlight in subsequent narratives, Kay leverages GC to access scholarships for broader and deeper participation in science.

Narrative of Navigation: Following my Mother and Sister into Science

So with patches on my britches
Holes in both my shoes
In my coat of many colors
I hurried off to school

Just to find the others laughing
And making fun of me

And oh I couldn't understand it
For I felt I was rich
And I told them of the love
My momma sewed in every stitch
And I told 'em all the story
Momma told me while she sewed

For the last four years, Kay has insisted that she wants to become a doctor when she grows up. She feels becoming a doctor allows her to help people stay healthy, and she wants to provide care for those who cannot afford it. For Kay, studying medicine seems to be more about helping others than it is about having a career.

Kay seems well aware of the challenges that lay before her in fulfilling her dream. She appears to find great strength to navigate this pathway from the women in her life, although admittedly her relationship with these women is highly complex. Kay speaks passionately about her mother and sister as educated women, for her mom went to college and her sister is currently pursuing a career in technology. However, when she elaborates on their academic tracks, she is uncertain about what her mother studied and tells us that (before she got sick and lost her job) she oversaw "stuff" at a pet store. Her sister, on the other hand, attends a part-time program at a fast-track career center, and aims for a technician degree. She refers to her mom and sister as "role models" who are leading the way with lives in science, and as individuals who are "trying to be their own person."

Kay indicates that her mom would be happy with any career decision that she makes, but is certain that her mother desires a better life for her than she has had for herself, "My mom doesn't want me to end up with a lifestyle like hers." For Kay, her mom's insistence in a better life and her own efforts to work in science are the "major thing that keeps me on track…I want her to be proud of me."

In her pursuit, Kay has inquired about the requirements for an M.D. credential. When one of the instructors at her afterschool program explains the 10-year lengthy process, Kay opens her eyes and says, "That's a long time." Not deterred, she indicates that she is pursuing a track different from her mother and sister, whose college experiences have been much shorter. She makes such note, not out of judgment it seems, but more out of thoughtfulness, expressing that they have set up the way, and she is going to push further.

Another important measure that Kay takes into account when she evaluates the information given by her instructor is the cost of those 10 years. With her family's limited income, she is keenly aware about the financial barriers to accomplish her goals, saying, "the biggest thing I need is money." Nevertheless, it is precisely at home where she receives the necessary elements to break them down, for she acknowledges that her mother's advice and "tough love" on getting good grades is directly related to possibilities of getting a scholarship. Taking her mother's advice to heart, she applied for and won, summer scholarships at [State Tech University], becoming the only youth who has won the award twice. Such strategic navigation

on Kay's part illustrates how she is driven and unapologetic in reaching out for resources that will give her a leg up to reach her goals. Kay is not passively "aspiring" to be a doctor; here is a 12-year old fighting tooth and nail to achieve while facing constant danger of being derailed any moment due to economic instability at home.

With her mother and sister as ever-present role models in science, and her increasing authority as a high performing youth in GC, solidified by authentic, rigorous experiences in science both at the club and during summer internships at a University, Kay has stitched reinforcing patches that position her as someone who has ability and can succeed in science. These elements are especially important navigation devices as they stabilize her identity as someone who can do science even as she struggles with her grades, her participation in school science, and with a tumultuous home-base situation.

Narrative of Protection: Creating a Place in Science

And I didn't have a coat
And it was way down in the fall
Momma sewed the rags together
Sewin every piece with love
She made my coat of many colors
That I was so proud of

While carving an inroad towards her science goals, Kay also challenges the boundaries of science both through the process of her engagement and in the science artifacts that she produced at GC. Doing so allowed Kay to draw attention to the strengths and resources she brings to science, resources that are not typically valued in the traditional discourse of science. Through the act of personalizing her science artifacts, Kay also positioned herself as a community expert with the authority to educate those around her about socio-scientific issues. While personalizing artifacts might have been the norm at the club, but how she did so, she continued to push on the boundaries of science. As she explains in a paper she wrote:

> My movie made a difference to many people. I know that my sister started to be more green by not littering and picking up trash. She would nag at her boyfriend and yell at others because he would liter and not take care of his trash. [M]y point is that being in Green Club and making movies has made me feel better because I know that I helped change the world. I made movies and people listened (from Kay's paper, March 2011).

As this quote suggests, Kay found opportunities to author multimodal artifacts for broad consumption to be central to her participation in her after school club. In talking about this work she positions herself as someone who is knowledgeable about science and who also has the power to make a difference. She references the power of knowledge in making change and challenges the viewer to consider what

knowledge matters as something that is contested. Kay takes a clear stance to show that scientific knowledge and decision is not cut and dry, that it involves emotions and thinking about the world from other perspectives (the polar bear); that serious messages about the world (global warming) can be shared through humor and wit as at the same time they lay down a sense of urgency.

Take, for example, the PSA that Kay made in 7th grade in GC ("The KCSTJ show"). The youth in the program were charged with crafting a PSA that educated others about "renewable energy." The youth investigated the role that green energy might play within their location, state and national communities, and its long-term impact on humans and the environment during the time of rising gas prices and intense national discourse on energy independence. Kay was particularly concerned that "getting green energy might not matter if people did not have the money." She noted that the local electric company charged higher prices for green energy, and that people might not understand that green energy not only saved the earth but really also saved money in the long run.

Thus, she co-authored a "radio call-in show" where they took calls on the listeners' views on renewable energy. The script positions Kay as the radio station DJ soliciting different views on green energy, as the song *Where is the Love* plays in the background (selected by the girls because it raises awareness on everyday actions in making the world a better place). She highlights the different stances that are likely to be held by her community members and provides a clear explanation for how one might balance these stances. Her attention is to both the community and the science around green energy alternatives, and to how such alternatives can be considered together with economic concerns rather than against them, as she has one of the "callers'" in her PSA note. In this one-minute PSA, Kay invoked science, peer culture, caring for other species and suggestions for how to ameliorate the devastating effects of climate change using their content understandings to build a coherent storyline that links everyday actions with climate change. This example reflects many other actions Kay took in the Green Club, where she sought to put different perspectives that are not normally found in scientific discourse side by side. We see this also in her narrative around creating a solar powered teen room at the club, where she hopes more kids will come so they will be "safe" and "off the streets" while keeping the earth "safe" from carbon emissions at the same time.

Kay puts her assumptions and understandings of science to use by enacting them and feeling pride in them, like the girl in Parton's song. Thus, the "science coat" she creates with her multiple understandings can protect her from a harsh world (i.e., a world with global warming and economic difficulties). Nevertheless, a harsh world can also be embodied in paradigms, norms, and conceptions of expertise that negate non-dominant forms of knowledge. For a girl like Kay, a hegemonic conception of science can be a harsh world as violent as a "rough neighborhood" if it is shaped as something that deems her inadequate, marginal, or even worse, non-existent. Her artifacts and subsequent insights are constructive efforts that give testimony of the way she defends herself and her community from both global warming and disenfranchisement.

Narrative of Endurance: Knowledge and Skills to Make Real Change

But they didn't understand it
And I tried to make them see
That one is only poor
Only if they choose to be
Now I know we had no money
But I was rich as I could be

Throughout the years that Kay has participated in the after-school program, she has become increasingly aware about the role that she plays as a scientific expert and communicator. Indeed, Kay's pursuit for a better world (both as an expert and educator) is directly related to the situations and corresponding tales that emerge from her home and her community.

In an interview that took place when she was in 7th grade, we asked her to tell us about out-of-school places or moments in which she thought about her learnings on green energy. Kay answered,

> Sometimes I think about it when I'm going to bed, it just pops up in my mind while I'm not thinking about anything else. And sometimes when I think about death, I think about global warming.

When we asked her about how that made her feel, Kay answered "mad" because she wants people to be more conscious about global warming and engage in activities such as recycling and carpooling. Later on, when we asked her if she wanted to continue attending the club, her answer took the interview in an unanticipated direction. Adhering to the relevance that testimonios give to the experiences of those outside academia and in order to convey the power of Kay's own words, we present the direct transcription of what followed from our question:

Interviewer [Int]: Umhm. K, and uh, looking forward, what do you hope to learn next year? Cuz of course you're gonna be in [Green Club] right?

Kay [K]: Umhm. I was thinking either in the fall or in the summer, it doesn't matter- I was thinking maybe we should talk about all the issues of death and different things that are causing um, people to die, like global warming, and well, I mean, I know that Green Club is about Green Energy Technology, but I think we should do a different subject.

Int: Oh you do? What's that?

K: Like, um, stuff that's causing different things to happen to people, like how people, why people are stalking, and why people are doing drugs and drinking, and a lot of stuff like that.

Int: Other kinds of problems in society?

K: Yea…

Int: Um…any other…?

K: Suicide.

Int: Oh. Wow. I think we'll probably have to stick with Green Energy Technology, but those are all really important issues that you're raising.

K: Yea, I was also thinking, I was also thinking about maybe asking Ms. T if we could start our own club.
Int: Oh on what?
K: Me and some other girls, maybe, if they wanted to.
Int: What kind of club?
K: What I just said.
Int: Suicide?
K: No, not suicide. A club about problems that's going on and then we should…
Int: Problems in society?
K: Yea and then we could make commercials and put them on TV and tell people they need- they just need to stop or…
Int: Umhm.
K: Or they could possibly die from it, because my sister um, knew this girl and she got mad at her mom, she went upstairs she took the um, what's that thing called when you go- it goes on your robe to tie it up…
Int: Oh, um, like a belt?
K: Yea, like the belt on the robe, and she tied it around her neck and she hung herself and her mom called the police and she was going upstairs, she saw her daughter and she was trying to take it off but it was too late, she died.
Int: Wow.
K: So yea
Int: That's upsetting, oh my goodness.
K: Umhm. So it was because she was mad at her mom, so I was thinking about starting a club, putting on commercials saying "don't do suicide, don't do drugs, don't drink alcohol, don't stalk. All this stuff could possibly get you in prison or jail, or you could possibly die from all of this." Because if you, I know stalking may seem like, 'oh no, you can't die from that' but you can, because what if that person sees you?' And you stalk them all the time, they might, they could possibly shoot you. Or kill you somehow. So I would like to start a club about that too.

From an early age, Kay has had to deal with figured worlds that have made her aware of the impacts of drug and alcohol abuse. The tales that she hears at home from members of her family include images of girls hanging from robe belts and people skulking in the shadows. She knows that the consequences of certain actions can result in imprisonment or bodily harm. Nevertheless, she is quick to affirm that her knowledge and skills are valuable sources to change those outcomes. In fact, the question that brought about her stories was the one that invited her to inquire into her future (i.e., "what do you hope to do next year?"). Unprompted, Kay brings up an extensive list of "problems in society" precisely because she wants to use her scientific/technological expertise to address matters that have touched her personally and significantly. Kay also feels empowered by her learnings at GC to want to leverage them in taking action for solutions. Just as she positioned herself as a community science expert with her PSAs, Kay wants to

reach out and share in the discourse on such societal issues pertinent to her and her community. Some of the concerns that she raised – drug and alcohol abuse – have strong connections both to science and her ambition to be a medical doctor. Thus, she portrays that her awareness, skills and voice can make a difference.

Kay's narrative conveys that the richness of the storytelling at home does not univocally communicate deficit. On the contrary, she takes those stories and situations as prompts to insert her actions meaningfully in the community to which she belongs. Thus, her present as a scientific expert and her future as a doctor are both functions of her current realities and her concern to change the world. Ignoring or dismissing her realities–whether her family's or her community's– would therefore be significantly detrimental to her (present) authoring and (future) participation in science.

The patches in Kay's coat reflect the many experiences that make up these narratives of protection, navigation and endurance. Kay's coat, which is a careful stitching together of these patches, protects and allows her to act significantly in an otherwise harsh reality that is, in part, the road towards a future in science. In the same way that a coat becomes indispensable when the temperature drops during the fall, recognizing the power in Kay's words allows us to imagine the way in which Kay understands and performs science/ technology as a way to shield herself and others from the "problems in society" she identified. Furthermore, if Parton's coat had the purported powers of "good luck" and "happiness" (precisely because it was created with the mother's love in that hypothetical family-figured world) Kay's coat protects her but also gives her the power to act from her understandings, her knowledge, and her priorities.

WHAT CAN WE LEARN FROM KAY'S COAT? TRANSFORMING THE HARSH WORLD

> Country music is music with a lot of class. It's just ordinary stories told by ordinary people in an extraordinary way.
>
> – Dolly Parton

As presented, Kay's life in science does not have a single origin and is certainly not monolithic. Throughout the 4 years in which Kay has shared her journey with us, she has drawn from often seemingly contradictory but nevertheless valuable resources that make her the insightful and promising 8th grader that she is today. Looking into her patchwork of experience allows us to understand the complex nature of constructing and re-constructing herself in science.

In the same way that Parton is an ordinary woman telling ordinary stories in extraordinary ways and speaks to and about a class through her country songs, Kay voice is a testimonio of and to a community of African American girls that she lives, learns and plays with. Kay, and many of her friends come to school – and to possible lives in science – without the traditional set of resources that research and/or society expect (and demand) if girls are to author a life in science. Kay's neighborhood is one of families struggling economically, in a city marked by high

unemployment and severe racial divide. This divide also plays out economically with more families of color experiencing unemployment at a time where state legislators are cutting social support networks. It also plays out in school enrolment patterns across the district.

And yet, the resources Kay gathers from her family, peers and club teachers in her out-of-school figured worlds provide her with resources that often run counter to the normative view of what families provide to support girls in science. Sometimes they run counter because the resources themselves are not themselves normative. Sometimes they run counter because Kay's pathway to the resources (both normative and not) are unexpected and complicated. These resources also provide Kay with the space to navigate and transform a possible life in science. Through her mother's and sister's experiences, Kay has taken on a wide view of "a life in science"–a PetCo worker and technician – being able to find role models whose lives are like hers, while thinking creatively about resources she might bring to succeed in science. Ultimately we see Kay as being able to re-write the narrative of success in science as something that is only for nerds or white people. Not unlike the counternarratives of successful African American achievers in math who resist and rewrite *"hegemonic notions that academic success is white property and cannot be attained by them"* (Carter, 2008, p. 477), Kay resists and rewrites notions of success in science.

Kay's stories should not be sensationalized, but neither should her accomplishments be read as "the myth of the American Dream." We rather understand them as a challenge to the deficit-oriented framing that some might take to understanding Kay's life. The very resources–material, cultural, symbolic–that compose Kay's coat when viewed through hegemonic narratives would be framed through the discourse of deficiency (single parent home, mother in low-wage work, sister not going to college). But such a deficit framing is myopic for it does not reveal how Kay understands these experiences and when and how she draws strength from them. These resources are woven in such a way that they are re/inscribed with powerful and productive meanings that open pathways for her and help her succeed. Such identity trajectory work emphasizes (rather than ***deflects***) how race/culture *and* science merge to transform being a "club kid" into a powerful and capable learner and doer of science.

Kay has sewn a coat that she uses to navigate, protect, and endure–and she has crafted it carefully, with love in every stitch. We wonder, however, if as teachers and researchers, we will "laugh" at the coats of our students because we do not understand them, as Parton discusses in her song.

After all, why would one consider a low-wage job at PetCo as a life in science? And, what happens when someone official–a teacher, a school counselor, or peer–informs Kay that her narrative is faulty? We also wonder if we will recognize our students' coats as coats, for if we fail to acknowledge the complexities of a metaphorical coat, we can also divest it of its power. We would rather advocate for classrooms in which girls like Kay's testimonies are seen as their possibilities rather than their rags.

NOTE

[1] We have followed Kay for four years (5th-8th grades), and have gathered hundreds of hours of observational notes across the figured worlds that make up her life, conducted multiple interviews each year with Kay, had conversations with family members, and have collected a wide range of artifacts from school and out-of-school spaces. Working with Kay and her data, we sought to trace out her participation in science class and in other figured worlds over time. The family-related out-of-school figured worlds differed for Kay, as they extended from her primary home with her mother and siblings, to her grandmother's, to her sister's. Using science events (within figured worlds) and Kay's identities over time as focal points in our analysis, we worked to discern patterns that mapped onto Kay's identities and her participation in an after-school science club, and to expressed forms of interest and participation in science.

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JRÈNE RAHM AND ALLISON GONSALVES

5. "TO UNDERSTAND THE NEWS YOU NEED SCIENCE!" GIRLS' POSITIONING AND SUBJECTIVITY IN AND BEYOND A NEWSLETTER ACTIVITY IN AN AFTERSCHOOL SCIENCE PROGRAM

Instructor	That's all you wrote?
Alana	Yeah
Ajala	Well, yes, we talk, we are girls
Alana	Yes, that's right
Instructor	No, you're not girls here, you're journalists! Then, later, you are girls! (giggles)
Alana	Yeah, later we are girls, at five thirty!
Instructor	So what is it, what is your article all about?

The brief exchange illustrates some of the positioning and subjective work that accompanied girls' engagement in the science newsletter activity in an afterschool program for girls only. One youth excused their talkative nature by labeling themselves as "being girls", a means of self-positioning that helped them save face in light of their slow progress on a draft of a journal article. Yet, the instructor geographically and temporally relocated that identity marker to the outside by adding, "later, you are girls!" Alana, the youth assistant and old-timer of the club expresses agreement with that relocation by repeating the previous statement, while further qualifying it by adding the time when the program ends. The exchange points to the designated identity of the newsletter writing activity that the girls were expected to take on. Engagement in girl talk positioned the girls as outsiders to the practice. The instructor's emphasis on the girls' position as "journalists" called for a different kind of work than girl talk. The brief exchange also illustrates a lack of critical reconstruction of positions and self-assigned subjectivities by the girls. The girls did not publicly question the fragmentation of their identities–as girls or as journalists but not as both. It left us wonder whether the girls had opportunities to explore what it means to be a girl or a journalist? Were there opportunities for the girls to explore ways they could be both, girls and journalists? It led to a focus on the kinds of cultural resources that were available to the girls in the newsletter activity and in the girls-only afterschool program through which positioning work took form. We were curious whether the girls had

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an opportunity to engage in a science practice they valued and that made identities as insiders in science possible and desirable.

We address these issues and questions through stories of girls' engagement with science in ScienceGirls, an urban afterschool program situated in an underserved community marked by immigration. In the first story, we explore Alana's discursive constructions of self in relation to the newsletter writing activity and in science in particular, as evident through her authoring of self and identity work in our interview dialogue, yet also her positioning in a whole group discussion and negotiation of a newsletter theme and deliberation with some youth about the appropriateness of a specific article and topic for the newsletter. In the second story, we focus on Kassandra, and her forms of engagement in the newsletter activity at its margin, as a youth uninterested in science. We explore the manner in which her subjectivity was crafted through her text but also in dialogue with the first author during an interview. The two girls acted from different positions within the established participation structure of the program. We examine the mediating role of cultural resources next to the ideology of science in their positioning work.

THEORETICAL GROUNDING

Numerous studies have explored the practice of positioning in afterschool programs and youth organizations (Deutsch, 2008; Weis & Fine, 2000). Grounded in the perspective of positive youth development, identity work in these studies is understood as taking form in interpersonal and intergenerational interactions among youth and adults, and in spaces where it is safe to be different and to play with identities otherwise not accessible. The most effective programs, in the eyes of youth, emerge and build upon local knowledge and identity markers and reinforce the vision of youth as resources "to be developed and as persons of value to themselves and to society" (Heath & McLaughlin, 1993, p. 59). Such programs are places that seriously engage with youth culture, that focus on youths' creative constructions despite material constraints.

Of interest in this chapter are the ways in which science and its associated practices are discursively constructed by the adults, youth and youth volunteers in the program, and how youths' participation in these practices intersect or are confounded by their participation in *youth culture* within the program. To discuss youth culture in a substantive way when doing research with diverse urban youth, it is necessary to keep in mind the plurality of ways in which youth engage in cultural practices at school, at home, with their friends, in community programs such that they construct and carry with them flexible and durable *repertoires of cultural practice* (Gutierrez & Rogoff, 2003). Additionally, it is important not to essentialize or take for granted either the concept of youth or culture (Bucholtz, 2002). A productive view of youth culture and youth identities is one that is concerned with local practices that constitute positioning and subjectivity.

To focus our gaze on the local, we emphasize the importance of space and time, both social constructs that have led to individuation and differentiation among youth in terms of learning and identity work in general (Harvey, 1990), and in

science in particular. The literature suggests that effective afterschool programs become places of voice and empowerment for disenfranchised youth given their geographical location within a complex web of practices that for the most part silence and sort youth out of science or even the educational landscape altogether. It has led to a discourse around out-of-school-time (OST) science programs as playing a key role in attracting young girls and other under-represented groups (youth of colour, immigrant youth) to the sciences, and in countering the documented under-representation of women and individuals from non-dominant communities in the science disciplines at tertiary levels (CAUT, 2009). While these programs have been successful in the recruitment and retention of some girls to science (Fadigan & Hammrich, 2004), OST programs also play important roles in science education beyond the pipeline goals. OST programs have the potential to disrupt representations of science as disconnected from students' lives and become sites to expand the borders of science and open up possibilities for marginalized students to take up identities in science, at least temporarily (Brickhouse, 2011; Calabrese Barton, 1998). This leaves us first, with a spatial question around ScienceGirls, and the manner it was socially constructed as a space to develop science literacy and identities in science. Second, given the opportunity for on-going engagement with science over time, it also becomes a question about time and how sustained engagement in the practice and its spatial dimension as a place of empowerment in science may add up and constitute the girls' positioning and subjectivity in and beyond science over time. It hints at the need to explore girls' learning and identity in ScienceGirls as trajectories (Nasir, 2012). Both are understood as dynamic and continuously changing over time, rather than static, and it is the study of that change over time that will offer deep insights into girls' positioning.

Grounded in sociocultural historical theory, we explore girls' positioning in and beyond science in light of their engagement in the newsletter activity in ScienceGirls. We draw upon the work of Holland, Lachicotte, Skinner, and Cain (1998) and focus on the dialogic relationship inherent to positionings and subjectivities. We explore the manner in which two girls in particular have been positioned by society, by the program, and by its instructors and peers, and how simultaneously, the two girls respond to such positioning through the creative construction of agentive selves. Hence, how their own subjectivities are created in response to being positioned in certain ways is the primary focus. It is the dialogic among the two that "contributes to the production of cultural forms that mediate subsequent experiences" (Holland & Leander, 2004, p. 127).

Drawing from Nasir (2012) and Nasir and Cooks (2009), we focus on the mediating role of two cultural resources: the relational resources, amounting to the interpersonal connections to others in the setting; and ideational resources, referring to the "ideas about oneself and one's relationship to and place in the practice and the world, as well as ideas about what is valued and what is good" (p. 44), in general, and in terms of science in particular. We explore the manner such tools are picked up or ignored and hence, constitute the girls' positioning work.

We also assume that such positioning work needs to be understood as grounded in the youths' histories and figured worlds–the kinds of meanings the youth have constructed of their worlds given their past and current experiences, and in light of ScienceGirls and the girls' figured worlds of science, journalism, and girlhood within and beyond the program. As Urrieta (2007) reminds us,

> Identity is also very much about how people come to understand themselves, how they come to "figure" who they are, through the "worlds" that they participate in and how they relate to others within and outside of these worlds. (p. 107)

Figured worlds construct subject positions by defining the appropriate content and practices for scientists, journalists and girls. They give a sense of what is possible, right and acceptable for youth to do as participants in the afterschool program. The figured world of science in the afterschool program that emerges and is co-constructed through interactions between youth, and between youth and adults then supports local understandings about what science is and what are acceptable and appropriate ways of doing science or being in science. In the context of the afterschool program, these figured worlds of science can enable or constrain youths' ability to experiment with definitions of science, and explore the boundaries of what constitutes science. Figured worlds are also overlapping, in this case figured worlds of science and youth culture being intermingled in complex ways yet constituting girls' positioning of selves. In light of this, we pay attention to the various ways that participating youth engage in *self-authoring* (Holland, et al., 1998).

The organizational structure of ScienceGirls itself is also crucial for understanding the girls' learning and identity work over time. At the time of the study, the two focal girls of this chapter, Alana and Kassandra, received support and guidance from the adult instructors in the program, yet, simultaneously served as role models for the younger participants. They had become youth assistants, an ascribed identity that Alana fully embraced while Kassandra struggled with its appropriation and enactment, given her peripheral insider status to ScienceGirls. Hence, Deutsch's (2008) "tri-level role modeling" describing relational participation structures in youth organizations is a cultural tool that also fits ScienceGirls and that helped us examine how youth construct new identity positions for themselves in relation to their assigned positions in the program. This analytic lens also helps us examine how youth adopt or challenge the ideational resources of acceptable ways of engaging with science in the program.

METHODOLOGY

ScienceGirls is an afterschool program that has been in existence since 1987, serving diverse urban girls from two elementary schools in an underserved community of Montreal. The program offers an array of science activities such as opportunities to engage in science experimentations, the pursuit of science fair projects, and the writing of a scientific newsletter. Through engagement in these

activities over time, the program supports the girls' development of competencies that will mediate their completion of high school and pursuit of higher education. Every afternoon, the program begins with a snack next to a period of homework help, and ends with a play period that many girls spend in the computer lab. Around 80 girls are signed up with 35 participating each afternoon. The girls range in age from 9–12 years and are ethnically diverse. Many girls participate for three consecutive years.

In this chapter, we focus on the newsletter activity, offering girls in 5th and 6th grades[1] opportunities to write about science, and girls now in high school to return to the program as youth assistants, helping newcomers in their writing. The newsletter entails reports on scientific topics and themes chosen by the girls and is targeted at elementary school children. Short texts with images, crossword puzzles, results from interviews, questionnaires or experiments conducted by the girls, represent some of newsletters' text genres. The director of the newsletter works alongside two instructors and occasionally a volunteer adult along with one or two youth assistants, to guide the girls' work on the newsletter. According to the two instructors, the newsletter activity offers the girls a way into science and supports the girls' science literacy development:

> To deepen their scientific knowledge, it's really important. When one understands what's around us, it gives us another vision of life. They are immigrants for the most part, we help them improve their French… the opportunity to make friends, to have fun, to be safe when parents are not home. (Sue)

> To help them develop a disposition to analyze and question things, to help them see themselves as intelligent enough to continue their studies; helping them understand that science is positive, that it's not complicated and it's accessible. (Kaja)

Through a video ethnography (video and fieldnotes), we captured the making of the newsletter during two academic school years: Two newsletters were produced in the first phase of our study (January–May 2009), one with a focus on Music, and another on Nature. In the second year (Fall 2009–June 2010) five newsletters were produced with the following themes: School and Science, the Universe, Biodiversity, Human Body, and Oceans and Continents. Through individual interviews of the twelve participating youth each year, we gathered insights into the discursive constructions of self and self in relation to science. We could also get a sense of the girls' history and personal constructions of science, both accounting for their figured worlds of self and science. Each year, approximately twelve girls participated in the newsletter activity. The girls had a diverse immigration history, with parents from Morocco, Congo, Caribbean, Greater Antilles, Bangladesh and Sri Lanka. In line with the language act that has been in place in Quebec since 1977, which proclaimed French as the official language of that province, all program activities have been conducted in French. However, code switching among French, English, Tamil, and Hindi was common.

Friday afternoons begin with a snack and discussion of the work to be done for the newsletter around a big table. After discussion of progress on their articles, choice of theme or article type, the girls continue their work in the computer lab. Many girls show up early, to surf the web, to spend time on Youtube and exchange preferred songs and videos, check email, or spend time on Facebook. Youtube videos of Bollywood music and stars are often shared, making the program a space to explore many dimensions of globalized youth culture.

Using Spradley's (1980) semantic analysis, we made a list of the forms of participation in science the program supported over the two years of data collected. We also assembled instances of ways of talking about self and self and science. We reduced that data set to instances that implied the two focal girls that were then transcribed. Two individual interviews form each girl and two focus group interviews in which the two girls participated, were examined in terms of talk about self, self in science, science, and forms of engagement with science in the program. The data were analyzed in French and the selected parts translated only for the purpose of this chapter. Pseudonyms are used for the youth and the program to ensure confidentiality. The stories we present in this paper are best thought of as a bricolage of representative pieces of the analysed data (Kincheloe & Berry, 2004).

RESULTS: THE MAKING OF FIGURED WORLDS OF SCIENCE IN THE CONTEXT OF THE NEWSLETTER ACTIVITY

The Story of Alana

Alana's figured world of science and authoring of self as an authoritative member. Alana was born in Montreal and was fifteen years old at the time the data presented here were collected (year 2010). Her parents immigrated from the West Indies when they were young. They own a restaurant in the city, and have additional clerical jobs. Alana goes to a French public high school and has always been in the academically enriched track. Alana participated in ScienceGirls since grade four. She writes the editorial of each newsletter and spends most of her time helping others with their texts. She has participated in the newsletter activity since its inception in 2004 given her interest in reading and writing about science:

> It's important to inform others about science, it's important to understand science. I like to read about different kinds of sciences and technology and I think all sciences are important, they help us understand ourselves, our environment, the society in which we live and the human sciences.

Alana perceived the newsletter as a means to share science with others and help them develop a certain level of science literacy. She strongly figures herself as a journalist inside ScienceGirls, as is also evident in her reflection about her best editorial:

> I think the one I like the most is my first editorial at the beginning of the school year [newsletter on school and science]. I like the length of my article,

> the manner I managed to engage the reader, I talked of myself, personally, I talked about others, and I like the manner I wrote it, the literary quality of it… comparing it with others, this one is longer but well structured and it shows that I put much effort into it.

Alana positions herself inside ScienceGirls as a journalist, underlining primarily the kinds of journalistic skills she managed well and that are needed for quality newsletter writing, with no reference to science. Looking beyond the program, her figured world of science and figured self in science is rather ambivalent:

> I do not have any passion for the pure sciences, mathematics, chemistry, physics, I prefer the human side of things, like sociology, psychology, at the limit maybe physiology but even that is too technological for me. I like thinking about things. So maybe medical doctor, sociologist or a prolific writer.

Alana's figured world of science, related to the ideational resources made available at ScienceGirls, aligns mathematics, chemistry and physics with the pure sciences. Alana clearly positions herself outside her figured world of the pure sciences. She purports to enjoy "thinking about things" and uses it almost as an excuse to position herself as interested in becoming a medical doctor, sociologist or a prolific writer. Yet, her figured world of science that nourished her perception as an insider was also narrow and never seriously contested despite her long-term engagement with science in ScienceGirls. Why the program did not challenge her identity outside of science yet nourished her insider identity as journalist might become clear as we explore forms of engagement that the program supported.

Alana's positioning within the tri-level role model structure. The following excerpt details a discussion initiated by adult instructors and volunteers regarding the youths' topic choice of the "end of the world in 2012" and associated paranormal activity. The youth wished to write about this prophecy in an upcoming newsletter, but the appropriateness of paranormal as a science topic was hotly debated among the different instructors participating in the discussion. The adult volunteer opened up the discussion by noting that they had talked about paranormal as a journal theme and that it was now time to discuss first, whether it is a theme they are interested in pursuing, and second, how they could treat it scientifically.

Samadara	If we talk about paranormal, I would say, like everybody will take a different topic like she would talk about 2012, we would take spirit, and then she will take something else, like that?
Adult Volunteer	Maybe. That's up to you all to choose, but the question that is interesting is to know how to treat paranormal scientifically given that we do a scientific newsletter. [off topic talk] So how could one go about treating paranormal scientifically?
Samadara	Well, one could say like 2010, it's not true, this, this, or that, or that…
Alana	But we do not know if it's true or not. [off topic talk]

Adult Volunteer	I think it could be very interesting to see how scientists explain some of these phenomena that others consider paranormal.
Samadara	Yeah, but then scientists say that spirits do not exist. So then, what will we do? We can do nothing! Forget paranormal.
Ajala	But spirits do exist!
Alana	Myself, really, I think it's a bit touchy this topic because
Adult Volunteer	But it's super interesting
Alana	It's a theme that divides us, but it's hard [many talk at the same time]

Samadara begins by offering an overview of the different topics that could be explored in a newsletter with a focus on the end of the world in 2012, with the understanding that this might still be a possibility for a newsletter theme. The adult volunteer does not challenge the mentioned topics but instead, reiterates her previous question about how one could treat "paranormal scientifically[2]!" Samadara suggests that an evaluation of its truth would make it scientific, hinting at Popper's view of falsification as being part of science. That argument is challenged by Alana, the youth instructor, who argues that "we do not know if it's true or not." By suggesting that this might be an interesting topic to explore to determine what counts as science, the adult instructor opens a door towards a larger epistemological discussion, but as soon as she suggests that the girls should explore how scientists address the paranormal, Samadara proposes that they pursue another topic. The ideational resources about science made available to Samadara through her figured world of science given her school and program experiences, offer no possibilities for more expansive visions of science in which paranormal could be explored scientifically. Samadara suggests that it is impossible to write about a topic that scientists say is not true. However, some of the other girls in the group disagree with this assessment and make attempts to keep the conversation going. In response to this, Alana makes numerous appeals to the appropriateness of the topic referring to it as a "touchy" topic, one that divides the group, and as challenging in light of its readership:

Alana	But we write the newsletter for elementary school children, fifth and sixth grade for the most part… If we tell them things like in 2012, everybody will die, they will freak
Adult Volunteer	But we cannot say, scientifically, that we will all die [other talk in background]
Alana	We cannot explain that. [everybody talks]
Director	OK. So we agree, we do not pursue that topic?

Here, we see Alana taking on a role of authority in the group, as she urges the girls to consider the effect this topic might have on a younger audience. She aligns herself with the argument put forth by the instructors and thereby also reinstates her position

and voice as a youth assistant who works at the elbows of the instructors. She also draws on both the ideational resources of what counts as appropriate writing in the program given the targeted audience, and what counts as an appropriate scientific topic as evidenced historically by past newsletters and topics for exploration in the afterschool space. In this way, Alana draws on the relational and ideological resources she has experienced as a participating youth and now youth assistant, and positions herself both as an authority figure in what counts as science and appropriate content. Her authority is further reinforced by the director's comment to not further pursue the topic. That comment by the director also positions the participating girls in problematic ways. It takes away the girls' sense of agency and empowerment, underlining some of the contradictions inherent to ScienceGirls.

In sum, Alana's self-authoring as a leader in the group is illustrated in the above two excerpts by her alignment with the instructors' argument about the inappropriateness of topic, but also her repeated focus and requirement that topics need to be explored in terms of scientific facts. She authors a position for herself in the figured world of the afterschool space that is both relationally authoritative, and ideationally defers to the authority of science and scientists as well as the adults in the club. This decision, supported by the adult interlocutors serves to reify a spatial ethos "wherein science teaching includes deference to the experts of science, which implies that scientific knowledge is not constructed by students, but rather delivered to them" (Seiler & Gonsalves, 2010, p. 100). There was no attempt to discuss what constitutes scientific facts other than a reliance on scientists as authority figures. In our attempts to understand why the instructors did not permit an in-depth epistemological exploration of scientific knowledge, we observed that the dialogue was fast-paced and punctuated by much laughter and jokes, indicating perhaps a willingness to engage the youth in this conversation about the appropriateness of the topic, but a missed opportunity to explore the boundaries of what constitutes science.

In another example, we saw Alana arguing against the inclusion of an article on Lady Gaga in the newsletter. She makes the claim that the article is not scientific and asks the girls:

> Alana Do you know what a scientific newsletter is? What's the difference between a scientific newsletter and a local low-end newspaper?

Similar to her response to the article on the paranormal, Alana's contribution reproduces the construction of a figured world of science that does not include references to pop culture or topics deemed inappropriate to youth and particularly girls. Her allegiance to the group appears unwavering, as does her figured world of science, in which writing a scientific newsletter carries more epistemological authority than other kinds of journalistic writing. The relational resources that Alana has gained during her time at ScienceGirls appear to have sharpened her ideas about what constitutes a scientific practice, as well as what may or may not be appropriate content for the projects the group undertakes. At ScienceGirls, Alana occupies a unique role–that of learner and of role model. Thus, we see Alana as occupying a unique space at the nexus of the figured worlds of science and

youth culture in the group, yet she appears to reproduce the ideas about science and appropriate content determined by the administrators of the program.

The Story of Kassandra

Kassandra's figured world of science and authoring of self at the periphery of ScienceGirls. Kassandra was 14 years old and finishing up her second year at a public high school. She was born in Beirut, Lebanon, and immigrated to Canada with her parents when she was two years old. She is Muslim but no longer practices her religion, yet does not want to lose it either. She shares a story about a boy in high school who called her "terrorist" once he knew she was Muslim: "He did not seem like he was joking, he was really serious about it, it was a bit irritating, a little bit, actually a lot." She then explains further how she is unsure about her religion, yet if somebody jokes about it in this way she could not just let it go by without challenging the person. This history demonstrates the ways politics and school talk are intertwined and the manner in which Kassandra herself struggled to portray herself given her history and now assigned position in Canada: as a first-generation immigrant, and living in an underserved community and in poverty making a University-level education possibly inaccessible to her in the future. Like many other Muslim youth, Kassandra struggled with discrimination and needed to develop adaptive strategies to negotiate her transnational experiences (Sensoy & Stonebanks, 2009). Given her situation, it might not be surprising that she sought out ScienceGirls, a space in which she did not feel judged. It was also an accessible space to her in a neighborhood with few other opportunities to engage with girls only in an activity that she could own in part. She enjoyed writing and hence, participation in the newsletter activity appeared sensible.

To do well in school is of high priority to Kassandra. She participated in most additional tutoring sessions that her teachers offered after class just to be on the safe side and do well in exams. As she noted, "I always panic when I have a bad grade." Kassandra felt the pressure to do well educationally, as is typical of immigrant youth whose families moved to improve the odds for a better future. Kassandra describes the neighborhood of her school, home, and ScienceGirls as full of poor people on welfare. She worried about high school given its public reputation and negative presentation in the news, "I really thought that there would be violence every day, lots of people that would hide weapons, well, I was twelve years old when I started there and quite naïve, but now I know this is not the case, even though there are some that smoke pot close to the metro once in a while."

Kassandra loves to write and hopes to pursue a University level education in creative writing if financially possible, "because me, I really like to write later if I can, I am not sure yet as a writer or journalist, I write stories from time to time and poems." Kassandra considers her mother over-protective and claims not to have talked to her father for over a year. When talking about her leisure activities, she discusses at great length her love for the arts and arts museums, and the famous

artists she has heard about and that make her want to visit New York and Paris, to see their original paintings. Kassandra identified with the newsletter part of the activity, while science itself (in the textbook format that she was familiar with) was not appealing to her. Kassandra clearly brought to the program a unique set of ideational resources for writing and participating in the newsletter activity, as one adult instructor summarized:

> I noticed that Kassandra has a romantic side to her, very poetic, it's true that she does not bring with her the same kinds of things as the other youth assistants, but she is very involved, she wants to talk, she wants to interact and provoke a bit also, to express herself.

Kassandra's interest in ScienceGirls appeared to rest in the opportunity to write and to participate in a safe, all-girls environment. Rather than relying on the resources that the program offered, Kassandra sought to find her place in the program by mobilizing her own resources and carving out a space that met the requirements of the program, but also satisfied her cultural interests.

Kassandra	Honestly, science does not really interest me, above all, I never had any good science teachers, there was just something that told me, 'why don't you join ScienceGirls', I just did it, there is no real reason really
Jrene	OK
Kassandra	But I like it here.
Jrene	Well, you already told me a bit what you like here, is there something that makes ScienceGirls special to you though, the fact that it is for girls only, is that important to you?
Kassandra	Evidently
Jrene	Yes?
Kassandra	Well, honestly, I try to…I do not really approach boys, I speak, often, I speak to boys sometimes, but I don't really have close friends that are boys. So, I do feel more at ease in a place with just girls.

Kassandra brings with her ideational resources about science that resulted in a figured world of a science that is abstract, disconnected from her life, and as a result, boring. When asked directly what came to mind when she thought about science, Kassandra responded that science to her meant "insects, and Louis [sic] Armstrong…you know, the first man on the moon? When I think of science I think of the moon, that is much bigger than me." Kassandra complains that at school, science is all about books and labs, and that "it's boring, because we work just… almost exclusively with textbooks and at one point, it becomes just really boring."

What made the newsletter activity accessible to her and brought her in was clearly not the science but the opportunity to participate with others girls in a space that she perceived as safe, and also a space she may want to return to later.

Kassandra	Well, I think this will not really count in my CV for the future to go to University, but I just wanted to try it.
Jrene	Will you continue next fall?
Kassandra	Well, I would like to become an instructor [in the program], not forever for the rest of my life but to have an education as an instructor, that would be great. So then once I would have my education as an instructor, I could come back here.
Jrene	Yes, that would be great. And how do you feel here at ScienceGirls? Do you feel welcome, at ease, comfortable it's my place [using cards with these words on it, asking youth to select]?
Kassandra	At ease
Jrene	Why?
Kassandra	Because I am familiar with the place, and also because there are no…the girls are mostly cool, "sympa" I am not sure quite how to say this…

Kassandra's participation in (and commitment to) this particular program raises questions about the goals of the program, particularly with regard to its emphasis on science.

Kassandra's goals for her own personal development in the program eventually appear to come in conflict with the ideational resources held by instructors in the program. Kassandra's desire to express her interest in writing poems dealing with the theme of love and romance initially conflicted with the instructors' wishes and program guidelines to restrict the girls' writing to topics related to science. In the end, spurred on by her interest in the Vermeer painting "The Girl with the Pearl Earring," Kassandra transformed the activity of writing a scientific text into a form that was meaningful to her, weaving into her poem a scientific account of where pearls come from. The translated text of her poem, entitled the 'Tear of Aphrodite' appears below.

The Tear of Aphrodite
It will be lucky
That little grain of sand
When it enters
Between the shell and the coat
Of this small oyster
That will cover it
Of carbonate
It will be lucky
That little grain of sand
When it crystallizes
When it becomes a crystal
In the shape of aragonite
Which is a mineral
And when the pearl

> At last comes out of that mold
> When that little thing
> So rare, so admirable
> And so precious to us all
> When with the other tears of Aphrodite
> It will grace the neck of a pretty damsel
> How happy she will be
> That little pearl!

The conflict that Kassandra expressed between her desire to create an artistic piece and the requirement that she conform to the genre of science writing deemed appropriate in the figured world of the after-school program led to an improvisational act wherein Kassandra combined her artistic interests and abilities with the kind of science advocated by the program. This enabled her own self-authoring as both an artist-in-residence and someone who engages in science through the use of poetry. Through her poem, she made public her desire to be recognized as a poet whose interest is in romance and wordsmithing. At the same time, she managed to fulfill the requirements to write on a scientific topic. This example of improvisation demonstrates the possibilities that exist for engaging youth in science through their own interests and desires in ways that expand the figured worlds of science and scientific writing in the local context of the afterschool program. Kassandra's participation in the newsletter activity brought her from a more peripheral position in the program to a more central figure through her contribution. The seamless connection she makes between art and science via the poetic rending of scientific information permits her to author herself not only as a science writer and poet, but also a contributing member of the science writing community in the afterschool program, a position in which she previously demonstrated very little interest.

Kassandra's poem was also noticed, as the interview with the director of the newsletter at that time suggests. She noted that her biggest challenge as a director of the newsletter activity was finding ways to go along with a strength and interest of a girl while ensuring the creation of a scientific text. In reference to Kassandra's poem, she noted,

> It really made me realize to what point you also have to be sensible to the talents of each girl…I watched Kassandra work on her scientific text and how she was not into it at all. She always walked around, talked to others, it took me much effort to help her concentrate and then, it finally worked for real, we made her focus on something she liked, in doing so, it worked, finally, she wrote the whole poem in one setting, it clicked for her. That's when I noticed how important it was that the girls pursue an article that has meaning for them.

Hence, Kassandra's agency was transformative and led to new possibilities of self-authoring and improvisation for other girls too. Such was most evident in the last newsletter of that year, with a focus on Oceans and Continents. One girl wrote

about her country of origin and its environmental challenges next to cultural practices, while another girl wrote a poem about the possibility of a future without water given pollution. It also led to a sensibility among the instructors to the diverse ways interests, histories and self-positionings of girls in science constituted the success of the newsletter activity. Yet, Kassandra's figured world of science is rather complex and may explain her fragile positioning inside science. Kassandra did not return to the program the following year. While she contributed in unique ways to the figured world of the newsletter activity and its community, she moved across that space quickly, unlike Alana, figuring it out quickly, on her trajectory toward adulthood, while also trying to claim a space in youth culture. It underlines just how complex space-time dimensions are in terms of identity trajectories. Time alone (i.e., engagement in program over time) was not enough to make insider status to science more likely as the comparison between Kassandra and Alana suggests. Yet, when juxtaposing the spatial dimension next to time, it is evident that the ideology of science of ScienceGirls as perceived by the girls given their history and figured world of science clearly made no desirable identities in science available to them.

DISCUSSION

The data presented in this chapter suggests that the figured worlds of science that girls like Alana and Kassandra constructed in light of their participation in ScienceGirls and as inspired by experiences with science elsewhere, reproduce the dominant framework of science "as a body of authoritative, incontestable knowledge which is abstracted from social activity to maintain a high level of difficulty and status" (Hughes, 2001, p. 276). The instructors at ScienceGirls working within this paradigm, seem to carry this particular ideational resource with them, and it appears likewise to be transferable to the youth instructors, particularly Alana. In a critique of the school science curriculum, Gilbert and Calvert (2003) suggest that rather than focusing on just the content of science, it is the teacher's responsibility to open up spaces that allow students to engage with the construction of scientific knowledge – to explore what counts as science. The data presented in this study makes a case for the extension of this form of science learning to OST spaces. The fracturing of identities associated with girlhood and the geographical localization of these identities (they are girls outside of the science club, but inside they are journalists or scientists) serves also to reproduce a figured world in which science is simultaneously authoritative and incontestable and something that *girls* don't do. One way to deconstruct this common discourse about girls in science is to widen girls' conceptions about what counts as science to include examples from their everyday lives and the cultural resources that they bring to the program (Calabrese Barton, 1998; Seiler, 2004; Seiler & Gonsalves, 2010). However, our findings suggest that the ideational resources about science that are shared at ScienceGirls are so galvanized, that starting science from the girls' lives became a source of conflict rather than an opportunity for discovery.

It is important to note that the instructors at ScienceGirls are operating under a specific mandate to encourage girls in science. This determines the kind of programming they run, and is limited by the funding available to the program. Like those reported by Davis (2002), the instructors at ScienceGirls face barriers including: insufficient community support and funding; mandates that are tied to the requirements of funding agencies; and conflicting ideas about how to best meet the needs of the girls in the program. ScienceGirls is required to support girls in their science learning through, in particular, a Science Fair program that has become the focus of the program given on-going funding for that project (Rahm, 2010). Thus, the figured world of school-science is carried into the OST space, complete with its material, ideational and relational resources that then mediate constructions of what counts as science. Most important, science in ScienceGirls is perceived as a tool through which girls may develop different kinds of competencies that help them stay in school and break out of poverty. Science literacy development itself is not the primary objective of the program. Despite program goals larger than science, there needs to be a much deeper deconstruction of masculinity and femininity to ensure the empowerment of girls beyond that space. The program was initiated at a time when offering access to quality programming was perceived as enough for moving towards equality (Brotman & Moore, 2008; Phipps, 2007). Yet, our analysis points to the active and agentive role the participating girls played in the program in figuring positions inside science. These improvisational moments occurred when the youth expressed desire to deconstruct science together with the adults. However, these educational opportunities and teachable moments, were often missed by the instructors given how tied up they were in the objectives of the program that did not evolve much since the program's inception.

Despite the limited view of science advocated at ScienceGirls, the space did offer to youth, from non-dominant communities, opportunities to explore science in meaningful ways, and to construct identities as insiders of science temporarily using non-traditional means. The case of Kassandra provides an example of how an OST program can facilitate engagement in science through youth culture. Yet, it is as if the program was a space marked by "transgression and reproduction" (Holland & Lave, 2001, p. 19). On the one hand, it offered them with a safe space to play with insider identities to science, such as knowing science, as being capable to engage with it and put it to use to explain phenomena that they valued and wanted to share with their audience through their newsletter. The girls clearly described themselves and could see themselves as users of science (Rahm, 2010). Yet, engagement in science in ScienceGirls was also marked by subject positions the youth experienced elsewhere and that they carried into this space. Alana and Kassandra distanced themselves from the pure sciences, a discourse and social position that posed limits to the potential growth and transformation that the program could support. In sum, the girls could engage in empowering science in that space by writing about science and by positioning themselves as journalists, but not beyond it.

As is, the results hint at the "splitting of social identities by geography" that Deutsch describes in her analysis of youth identity work in a community program (2008, p. 92). Following that argument here, one could say that avoidance of "negative Othering" (p. 94) marked the youths' talk about their positions in and relations with science. They pretended to be partial insiders and engaged in what Fine and colleagues (2000) have termed "homesteading"–the use of a shared space to construct positive identities in science that may not be recognized outside of the program. Yet, when thinking of their future, ascribed social identities such as being girls or being girls who talk and lack an interest in science, were the identities that appeared available to them and which right away erased their potential fragile insider status to science that the program made them experience temporarily (i.e., as users of science). In short, they faced triple barriers towards an insider identity in science as girls, first generation immigrants and girls of color. In many ways, our study speaks to some of the complexities inherent to conversations about gender and science as summarized by Brotman and Moore (2008) and also discussed to some degree in the afterschool science program literature (Davis, 2002; Fadigan & Hammrich, 2004; Fancsali & Froschl, 2006; Rahm, 2010). Yet, our study suggests that the discourse around out-of-school time programs in science for girls needs to become much more nuanced through critical studies of the complex interplay of gender, ethnicity, figured worlds of science and identity in science. The chapter offers an attempt in that direction, yet much work remains to be done to move from such an analysis towards change and action in order to make engagement with science a possibility for girls in out-of-school contexts.

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NOTES

[1] In Quebec, high school begins when youth enter grade 7, and goes up to grade 11, at which point students have the option to attend CEGEP, a two-year college (and pre-university) program.

[2] Here, we wish to refrain from assessments about whether paranormal activity should be presented as a "scientific" topic, and rather examine the opportunities the youth had to debate and discuss the validity of the topic. The ongoing contention by youth that paranormal activity should be included in science classes raises questions about how we draw boundaries around what counts as science, and what value we place on resources youth bring into science spaces.

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6. YOUNG CHILDREN'S MULTIMODAL IDENTITY STORIES ABOUT BEING SCIENTISTS

INTRODUCTION

An important goal of science education is helping students develop sophisticated understandings about what science is, how it is done, and for what purposes (National Research Council, 1996, 2012). Just as importantly, science education should help students imagine themselves within scientific activity, including considering what counts as science in and out of school in more robust ways (Bang & Medin, 2011). In this chapter, we present findings from a series of interviews, given three times throughout one school year, that asked 54 children in six classrooms, grades 1–3, to draw and talk about two times they were scientists. We also asked how what students did as scientists was similar to and different from what scientists out in the world did. We call these articulations "identity stories" because through them, as students told about their participation and the participation of others in social practices, they constructed worlds with particular ideological commitments to the nature of science and their relationship to it, narrating themselves and others, particularly practicing scientists, as kinds of people.

Researchers have analyzed drawings to explore children's conceptions of standardized testing, technology, student teachers, and subjects in school such as math and reading (Haney, Russell, & Bebell, 2004). Pictures have also been used to examine young children's general conceptions of literacy (Kendrick & McKay, 2004), family literacy (Kendrick, Anderson, Smythe, & McKay, 2003), and their memory of events (Calvert, 1995). Over the past 50 years, most of the research using children's illustrations about scientists has focused on stereotypical indicators, specifying various characteristics students attribute to scientists, including scientists as loners and eccentrics (Finson, 2002). The Draw-A-Scientist Test, DAST (Chambers, 1983), and its adaptations and supplemental interviews (Sumrall, 1995) reveal children's stereotypes about scientists in terms of appearance, race, gender, work setting, and so forth. However, these studies offer limited understanding of children's epistemological beliefs of science and especially of children's own identities as scientists.

In our research we focus on how students conceptualize *themselves* as scientists in and out of school. Barman (1999) found that primary grade students represented themselves doing science in school as participating in hands-on activities about

M. Varelas (Ed.), Identity Construction and Science Education Research: Learning, Teaching, and Being in Multiple Contexts, 79–95.

85% of the time and textual activities about 15% of the time. However, he also classified students' reading and writing as "passive" activities (p. 46) and did not delineate how students thought of these activities as part of science. We certainly consider reading and writing to be active endeavors in which students construct scientific knowledge. The important research aim, for us, is to understand how students think they engage in science in the various activities that they bring up and label as scientific. Furthermore, rather than directing students to focus on what scientists look like, we asked them to focus on what scientists do and for *what purposes* they do it, positioning their own selves as scientists.

MULTIMODAL IDENTITY STORIES

Within educational research, there is increasing emphasis on the need for multimodal ways of expressing ideas, beliefs, and knowledge (e.g., Kress, Jewitt, Ogborn, & Tsatsaralis, 2001). Conceptualizing students' interviews around drawings as multimodal identity stories offers, we claim, a useful frame for examining students' emerging present identities and possible future ones. Identity stories are told dialogically, in interaction. They are multimodal kinds of small stories that can be as short as an utterance or a drawing (Bamberg, 2004; Tucker-Raymond, Varelas, & Pappas, 2007). Identity stories may be conceptualized as multi-dimensional representations of kinds of people engaged in kinds of social practices over periods of time (Lave & Wenger, 1991). They are made of our own representations of self, others' representations of us, and our own performances of self in social interactions (Tonso, 2006). This is consistent with an ecological view of communities in which the languages, belief systems, and specialized discourses and practices of communities that people inhabit shape their identities (Bateson, 1983; Lemke, 2001). Identity stories are representations of self, "the set of meanings we hold for ourselves when we look at ourselves…our observations of ourselves, our inferences about who we are, based on how others act toward us, our wishes and desires, and our evaluations of ourselves" (Stets & Burke, 2003, p. 130), in relation to a particular social setting. In our interviews, identity stories were constituted through spoken language, written language, drawn pictures, their interaction, and the meanings the student, the interviewer, and the analysts made of them.

We asked students to draw *and* talk about their ideas of themselves as scientists because we wanted to give them the opportunity to express their ideas in as many ways as possible. The modality of images allows different kinds of meanings to be made than the modality of verbal language. Images allow students to see themselves differently than words do. In turn, researchers are also able to see students differently. Furthermore, different modalities can work together to create a multiplicity of meanings as Lemke (1998) demonstrates in his analysis of multimodal reading paths in science textbooks. In our interviews, the students moved between visual and verbal representations to tell us about specific times they were scientists engaging in scientific activities or about situations in which they wished to engage in the future. They were able to build meanings from both

the spoken words and the illustrations to craft more substantive identity stories. The interviews themselves, and their analysis, were also multimodal. They were constructed not only from the words the students spoke, but also from the pictures they drew, the words they wrote, *and* the interplay between the different modalities of communication as the interview was being constructed. Modalities other than spoken or written language allow potential for meanings that also represent children's sense of these modalities. As Kress and van Leeuwen (1996) note, "representation requires that sign-makers choose forms for the expression of what they have in mind, forms which they see as most apt and plausible in the given context" (p. 11). Visual representation and language bring out two sets of meaning that Kress and van Leeuwen claim are neither "fully conflated, nor entirely opposed" (p. 18), thus being useful in offering us multiple, related windows into students' minds.

Although words and images offer different potential for meaning, a student's drawing as scientists can be as much a narrative representation as a verbal story. In our interviews, the students moved between visual and verbal representations, creating a multiplicity of meanings (Lemke, 1998). In almost every single one of the drawings, the children's representations contained an actor (the student) engaged in behavioral (i.e., making, exploring) and/or mental (e.g., thinking) processes for a goal or future outcome (i.e., to find out about worms, to help people). Such representations became identity stories about the actors in the illustrations, the students themselves.

According to Sfard and Prusak (2005), identities can be differentiated into two types, *actual* and *designated* identities. Actual identities consist "of stories about the actual state of affairs. Designated [identities] consist of stories which, for one reason or another, are *expected* to be the case" (emphasis in original, p. 18). In our study, we use the concepts of actual and designated identities to consider the narratives that students identify as belonging to scientists out in the world (designated) and narratives they identify with their own past and present (actual) and future (designated) identities. Identities develop from personal experiences inside and outside of school, from family members' experiences, from media sources, or any number of daily interactions a child has. Within this framework, then, we must consider how school experiences influence actual and designated identities, how identities might be different at the beginning and the end of a school year, and how students come to see the relationship between their actual identities and the identities they designate to scientists out in the world as they experience school science.

In the context of an interview, identities that count are the ones that are reifying, endorsable, and significant to a child (Sfard & Prusak, 2005). Identity stories are based in part on whom children are speaking with, as they make choices to represent themselves. Within the configuration of these choices lie their ideological commitments about the nature of science and their participation within it. Through this ideological positioning, they represent themselves as certain kinds of people who practice certain kinds of science. These representations are influenced by curricular and instructional practices that are enacted in the institution of

schooling. Thus, children's scientist identity stories are subject to, and constructed within, the production of the ideological, material, and interactional spaces. In this way, identity-story formation is a coordination and negotiation between how individuals recognize themselves as embedded in the world and how others recognize the world as embodied by individuals (Brickhouse, Eisenhart, & Tonso, 2006).

Our research questions were: In what ways do young children represent themselves as scientists? How are these representations similar to, or different from, their beliefs about scientists out in the world? To answer these questions, we present two kinds of data. First, we bring together and analyze data from all of the interviews. Second, we present the case of one 3rd grade boy to explain nuanced ways in which students articulated identity stories in the interviews. Our focus was on children in urban classrooms, many of whom are children of color who also live in poverty, because they have been repeatedly labeled as "underperforming," "struggling," and "under-qualified" when it comes to science, and we want to challenge these positionings.

BEING-A-SCIENTIST (BAS) INTERVIEWS

This study took place within a larger project entitled "Integrated Science-Literacy Enactments" (ISLE)[1] (see also Kane, this volume). ISLE centered on two extended science-literacy units, which teachers and university educators designed together. Each unit was about 10–12 week long and incorporated the following features: (1) hands-on explorations with whole-class discussions; (2) interactive read-alouds using children's informational books; (3) many writing (and drawing) experiences related to the inquiries; (4) small-group literature circle inquiries using informational books; and, (5) home projects that included a science activity and a related children's literature information book. The Matter unit centered on characteristics of matter in different states, changes of states of matter and how they take place, and how these changes are related to how rain is produced. Discussions on weather provided one of the contexts for this unit. The Forest unit centered on plants and animals that live in a temperate forest community–their characteristics, classes they belong to, and relationships among them, including food chains and webs. The units engaged children in both inductive and deductive dimensions of science, without, though, any engineering-focus activities. For more details on the nature of the project, see Pappas, Varelas, Gill, Ortiz, & Keblawe-Shamah (2009); Varelas, et al., (2007, 2008, 2010); Varelas & Pappas, (2006); Varelas, Pappas, & Rife, (2006); Varelas, Pappas, Kokkino, & Ortiz, (2008).

The Being-A-Scientist (BAS) interview asked students to think of two times they were scientists and then to draw pictures about those times. After children drew their pictures, they were asked to tell the interviewer about each of their pictures and explain how they thought of themselves as scientists in each picture. The interview conversation was about the pictures and the similarities and differences between the processes, circumstances, and epistemological stances students associated with actors in the pictures and those of scientists out in the

world. The children were asked to clarify if their drawing was an occasion that had taken place in the past or it was something they would like to do in the future. Furthermore, they were asked: "Why do scientists do the things you showed?" "Are there things that scientists do that you didn't put in your pictures?" "Are there things in your pictures that scientists don't do?" The same protocol was used for all three interviews. The interview was administered three times: (1) at the beginning of the year, before two science-literacy curricular units (PRE), (2) mid-year, after the first unit and before the second unit (MID), and (3) at the end of the year, after the completion of both units (POST).

Participants included 54 children, ten in each of five classrooms (two 1st grade, one 2nd grade, and two 3rd grade) as well as four children in one 2nd grade classroom, all in public schools in a large Midwestern city. One classroom in each grade was 100% Latina/o. Additionally, the 2nd grade class with the four student interviewees was a bilingual class in which students and the teacher mostly spoke Spanish to one another. Interviews were conducted in the language each student felt most comfortable using. One 3rd grade classroom was 100% African American. The other two classrooms had children from diverse ethno-linguistic and socioeconomic backgrounds with an average poverty level of 50%, in contrast to the average of 96% among the other four classrooms.

All interviews were transcribed. We then analyzed the transcribed interviews and pictures through a thematic content analysis. We were as concerned with the actions and goals of the actors in the drawings and associated talk as we were with their accoutrements. Each transcription of each interview was read line-by-line, and then divided into meaningful analytic units that were then coded by the research team. Considering both children's drawings and their discussions of these drawings, and guided by the constructs we discussed earlier, we developed a coding scheme that included the following categories: (a) the *when* and the *who* of each activity–whether the activity in the drawing was experienced, and if so whether it was experienced by the child or by somebody else, or whether the activity would be done in the future; (b) the *where* of each activity–whether the activity was (would be) done at school and being related to the ISLE curriculum, at school and not related to the ISLE curriculum, or outside of school, or not specified; (c) the *how* of each activity–whether the activity was a hands-on one, one involving print material, one involving other media, or not specified; (d) whether or not the child portrayed him/herself in the drawing and whether or not the child talked about him/herself during the interview; (e) whether or not others were part of the activity depicted in the drawing and expressed in the talking about the drawing; (f) the artifacts involved in the activity and depicted in the drawings; (g) the actions depicted and discussed that were part of the activity; and (h) the ways of being/identifying with science.

We also coded the stance towards the goals of science depicted in each activity using the following codes: Inductive Explorer (IE)–the people in the picture are engaged in exploratory activities and do not have *any* explicit ideas in their head about what might happen (e.g., mixing liquids to see what happens); Deductive Tester (DT)–the people in the picture are trying out activities because they have an

idea of what might happen and they want to test it out (e.g., mixing liquids of different colors will turn them yellow); Problem Solver (PS)–there is something the people in the picture need to fix (e.g., cure for aids, computer programming bugs); Engineer (ENG)–people in the picture make things to serve certain functions (e.g., robots to serve breakfast); Knowledge Developer (DK)–when the child has given some response but we do not have enough to place it in one of the other categories (e.g., scientists read to know more); Knowledge Presenter (PK)–when the emphasis is in the sharing of knowledge with others as opposed to developing the knowledge (e.g., scientists write books to share what they know with other people); and Not Enough Information (NEI) when we could not determine a stance from the available information.

To further explore differences between engaging in scientists' activities and students' emergent development of sophisticated concepts about scientists' work, Hogan (2000) proposed two categories of students' understandings of the nature of science–distal and proximal knowledge–to depict the relative distance of such knowledge from personal, lived experience. Distal knowledge is students' knowledge of the practices, products, and habits of mind of the professional scientists. Proximal knowledge is students' knowledge of the practices, products, and habits of mind that they themselves use, develop, and think about in their own activities that they recognize as science. To understand children's emergent proximal and distal knowledge, we coded the comparisons that children explicitly made between the activities they depicted and what scientists out in the world might do or not do–that is, between their proximal or actual and distal or designated conceptions.

We used the following eight codes, based on different types of actors, processes, and circumstances used in the English language, adapted from Halliday and Matthiessen (2004), as well as those that emerged from the settings of the students' pictures. Actors included whether or not the students included themselves and anyone else they may have depicted. Processes included: (1) material (acts on or with artifacts, e.g., mixing, pouring, observing); (2) textual (acts with print, images, or other media, e.g., reading or writing a book); (3) cognitive (references to thinking, knowing, understanding); (4) social (acts with other people, e.g., working with partners); (5) affective (description of feelings, attitudes, emotions, e.g., smart, cool, excited); outside); and, (6) verbal (verbal language, e.g., talking or answering questions). Continuing this list, circumstances included: (7) material artifacts (tools, equipment, materials, e.g., magnifying glasses, bowls, food coloring); and (8) physical environment (places where activities are done, e.g., at my home kitchen).

For most categories the major unit of analysis was each picture, as well as talk about that picture, that the student shared during an administration of the interview. However, both pictures that a child shared during an administration of the interview were coded together for students' *proximal* and *distal* relationships to scientists out in the world, (e.g., the question "Is there anything scientists do that you didn't put in your picture?" which was given at the end of the interview).

We analyzed the data in both qualitative and quantitative ways that included analyses of variance (ANOVAs) for each of the codes mentioned above to determine if there were statistical differences in regards to time (PRE, MID, POST), classroom, grade, gender, and ethnicity. In the Findings, we indicate the effect sizes for differences significant at or below the .001 level.

As we present the results below, keep in mind that the context in which students told us they were scientists was important in shaping the trajectory and legitimacy of these young children as scientists. The interviewer and the child together, in the context of school as an institution and the ISLE curriculum as science, constructed the identity of the child as a scientist. Furthermore, the children's own interpretations of what it means to answer the directive "I want you to think of two times you were a scientist" also shaped the narrative that they drew and told.

FINDINGS

In this section we present findings looking at our data from two lenses. First, we present some of the statistics from our analysis across students' interviews. Second, we present a case study of one student to provide examples of the nuance and complexity of individual responses.

Representations of Scientists Across Participants

The data we present are, for the most part, percentages of total number of drawings, in each of the three interviews, PRE, MID, and POST. Results from each interview in each analytic category that we present here are placed side by side to show how student responses changed from one interview to the next. In describing the results, we refer to "drawings," yet mean "drawings and any talk about the drawings between the interviewer and the student."

The more students participated in the ISLE curriculum, the more they drew themselves as having been scientists (PRE: 61%; MID 80%; POST 90%). Changes reflected a statistical significance in a linear trend from pre to post (effect size = 0.42, $p = <.001$), Furthermore, students learned what science was through the curriculum. Students' inclusion of ISLE curricula activities as the sites of their "scientistness" increased over the course of the interviews (PRE: 1%; MID: 43%; POST: 70%; Effect size from Pre to Post: 0.63, $p < .001$). There was a decrease of percentages of drawings that took place in school but not in ISLE (PRE: 11%; MID: 5%; POST: 3%) and that took place outside of school (PRE: 36%; MID: 26%; POST: 18%). The percentage of drawings for which there was not enough information to determine the place of the activity also decreased significantly from each interview to the next (PRE: 52%; MID: 23%; POST: 9%), indicating that students were much more able to explain details of their activities in later interviews, after they had experienced the ISLE curriculum. As students participated in the ISLE curriculum they drew significantly more activities that they had already done and drew significantly less activities they wanted to do in the future (Pre to Post effect size = 0.22, $p = <.001$). That is, students had a better

idea of what science was and where it took place. As their school experiences were seen as doing science, they referred less and less to activities outside of school. However, some, like Andres in the case study we present later in this chapter, were able to integrate practices from ISLE into their out-of-school lives and vice versa (see Andres's MID).

In each interview, hands-on activities dominated the percentage of total drawings (PRE: 79%; MID: 79%; POST: 85%) while print activities remained a small portion (PRE: 16%, MID: 13%; POST: 13%). Activities that were hands-on explorations included dissecting a frog, taking a bath and washing with shampoo, making a bird feeder, going shopping, "trying to build something from outer space with string and different colored balls" (Antonia, 2nd grade) and "mixing things together to see what color they make" (Jonah, 3rd grade). Print activities included drawing, coloring, "making books about what we are going to do," (Cassandra, 2nd grade), and "reading and writing about science movies" (Rhonda, 3rd grade). However, in both cases, students moved from drawing general activities (e.g., mixing potions) to more canonically scientific ones (e.g., observing evaporation, writing a book about owls).

We also coded the processes students represented in their interviews. For instance, articulations of thinking and learning were coded as cognitive processes. Examples of student responses that referred to cognitive processes included 3rd grader Kenny's, who said that scientists engaged in experiments, like the one his class had done on evaporation, "so they could learn from it" and "teach themselves about evaporation." Similarly, in a 2nd grade class, Natasha said that scientists "*figure out* what things can evaporate and what cannot" as well as "how water turns to steam." Students' references to cognitive processes, almost absent in the PRE, were coded 36 times in the MID. Ninety four percent of codes for cognitive processes reflected similarities students perceived between themselves and scientists out in the world. In the POST, the number of students' initiations of cognitive processes rose to 58. And again, the vast majority of these, 90%, were similarities. Student descriptions of reading and writing also increased to 15 total instances in the POST. For instance, 1st grader Jamar said, "scientists have to draw every day or once a week." Sally, in 3rd grade, evoked recording data when she said that scientists "fill out how many times the water evaporated." Eighty percent of students' descriptions about reading and writing processes were similarities. Mentions of how students felt about doing science (e.g., "Science is cool!") also increased in the POST to 21 overall. Ninety percent of the emotions they felt were similar to ones they associated with scientists out in the world.

In terms of social aspects of science, whether or not actors in the pictures worked with others, students were more likely to talk about (Pre: 42%; Mid: 61%; Post: 69%) but not necessarily draw (Pre: 23%; Mid: 29%: Post: 25%), more than one person in their pictures after participating in the *Matter* unit, and again after participating in both the *Matter* and *Forest* units. The change from pre to post was significant at $p = <.001$ level with an effect size of 0.27. That is, as they participated in ISLE, students saw science, and their participation in it, as a more

social activity that included group work. But we were only able to understand this because we asked students to talk about as well as draw responses to our questions.

In regards to epistemological stances that students took toward science, Inductive Explorer and Deductive Tester stances increased from four percent of the total number of pictures to 14% and 29% of the total number of pictures respectively. Engineering stances dropped from 13% of the total pictures to 3%, a viewpoint not reflected in the ISLE curriculum. Our analyses also point to the variety of ways in which young students saw aspects of their "sciencing" as different from that of scientists, mostly in terms of the artifacts of their activities, yet at the same time felt they thought like scientists, socialized like scientists, read and wrote like scientists, and were affectively engaged in their subject matter in ways that were commensurate with the activities of scientists out in the world. That is, they acted like scientists out in the world, but they just used different tools. Overall, students felt that they had been scientists, or at least had engaged in the kinds of practices that scientists do. We next turn to the case of Andres to explore in more detail how individuals told identity stories about themselves and scientists.

Case Study: Andres

Andres was a third grade boy who attended a public school in a large Midwestern city that served primarily Mexican American students with a poverty level of 95%. Ninety seven percent of the students in Andres's English only class were Latino/a. Andres's teacher was part of a group of six teachers working with the ISLE team to develop, implement, and study the science-literacy curriculum.

Near the top of his class academically, Andres was a frequent contributor to class discussions and small-group interactions. He also worked independently, writing his books and journal entries with enthusiasm and competence. Andres's verbal skills, his ability and willingness to share his thoughts, and his general amiability made him a good candidate for a focal student. We chose him as a telling case study because of the rich descriptions Andres was able to provide and because each of his drawings focused on different activities and, thus, included a range of elements of scientific practice. Some of the findings in Andres's case also reflected nuances of the findings from across the participants. Andres cooperated during his interviews and even seemed to enjoy the one-on-one time with the researcher.

In his first interview picture (Fig. 1), Andres drew himself going to the store. When asked by the interviewer (the first author of this chapter) how he was a scientist in the picture, Andres said, "my mom told me to get milk and I went to the store all by myself. So that way I could get something." Andres's vision of science, although not in any way canonical, was related to independent actions in which he was trusted with responsibility to carry out actions independent of his family and his home. There was not enough information from the interview to assess Andres's stance toward science.

Andres was the major actor in the picture, but not the only one. He also drew the clerk in the store. The store, although smaller than his house, is given more inside

detail. Such detail—the clerk standing behind the candy counter, and the box in the top right of the store, where "the milk is," locates the inside of the store as a major place of action, as opposed to his home. Pictures lend themselves to capturing moments in time, or snapshots. Andres's choice of what moment to capture was significant. Andres drew himself on *his way* to the store. Even though getting the milk for his mother was important, it was the actual going out by himself that Andres chose to express.

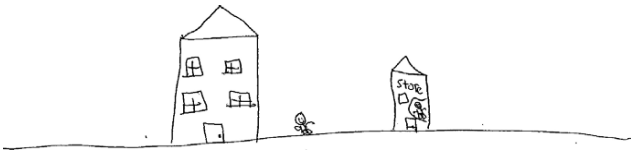

Figure 1. Andres's PRE illustration.

When asked if there were things that scientists did that he did not put in his picture, Andres indicated that he had not included "the sky and everything." Andres also indicated that scientists "do better pictures than I do." Attention to drawing or illustrating as part of scientific activity, even though only alluded to here, was significant in many of the PRE interviews. Students connected science with art, or scientists with artists.

In the MID, Andres again drew one picture (Fig. 2). This time, Andres drew himself doing something he said he had done before, observing a puddle. We coded this activity as developing knowledge about a phenomenon.

Figure 2. Andres's MID Illustration.

Even though he did not represent an ISLE activity, he did include concepts that he had encountered in the ISLE curriculum including the water cycle, evaporation, and the particular word, "droplets."

> Well, I thought that I was a scientist because most of the people that are scientists like they see what's happening. So I'm seeing little droplets are going up from the puddle going all the way up [traces finger up the page] to the clouds and then once it gets really full the rain is coming down…These circles are the little droplets that go up into the air.

In his picture (Fig. 2), Andres drew himself standing on, or near, a sidewalk, in the rain, holding an umbrella. His body occupied the right half of the illustration and the puddle with molecules "going all the way up to the clouds" occupied the left. The two major components of the picture were equidistant from the center to the margin of the picture and this suggests equal importance. Together with his talk about his picture, we inferred that for Andres, natural phenomena, such as aspects of the water cycle, are of interest to scientists who "see what's happening." Andres is a scientist who observes the natural world. Science, in Andres's picture, is the study of the natural world in order to understand it and possibly tell others what has been learned; it includes presenting knowledge that is consequential for people. Andres is a scientist because he is doing those things. When asked why scientists do what he had drawn, Andres said:

> Because that way they could write down the information. So that way if somebody calls them to see what's the weather gonna be they could say it on the news and they'll know it. That way they could see what they're gonna wear.

Andres's reference to weather is not surprising. Rain and evaporation were anchor concepts for Andres and served as hubs for the *Matter* unit ideas. His class had spent a good deal of time observing, reading about, and talking about the weather. In particular, he had constructed his own weather observation chart in which he had written down the weather on certain days. The class had also discussed weather during read-alouds, such as *Down Comes the Rain* (Branley, 1983). In this book, there were many pictures of children holding umbrellas standing in the rain.

Books were important identity-constituting resources for students. Two of the last activities in which Andres participated in the *Matter* unit, the literature circle and his own illustrated information book, were oriented toward rain. During literature circle, after reading with his group, Andres shared three sticky notes with the class: (a) "I never knew that when there's lots of clouds it might rain." (b) "The thing that is interesting is droplets can float." (c) "Why can't you see water vapor in the air?" Likewise, in writing his own illustrated information book, which he entitled "Particles and Rain," Andres was video-recorded numerous times going to look at classroom books to inform his own writing, using them as resources in making his own book. When asked about the differences between the picture he drew of himself and the practices of scientists out in the world, Andres could not

come up with any. What he had drawn was what scientists did. In this way, Andres totally identified himself with scientists.

In the POST, Andres drew two pictures from ISLE units (Fig. 3).

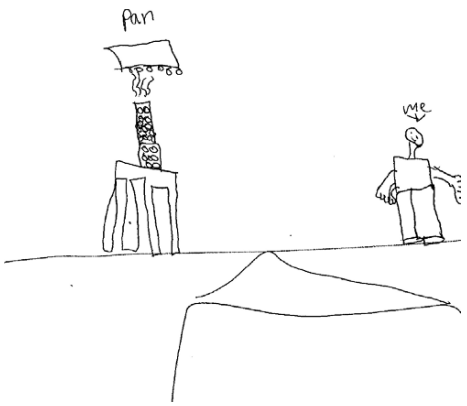

Figure 3. Andres's POST illustrations.

The top picture, the first picture he drew, represented Andres participating in an activity about water condensation from the *Matter* unit in which students watched water droplets form on a cold cookie sheet placed by the teacher over boiling water. In the bottom picture, Andres drew himself participating in the take-home project in the *Forest* unit, Growing Lentils.

The first picture of the POST was similar to the MID in content and was coded as a developing knowledge stance. Andres depicted water evaporating and condensing, a mini-water cycle. However, this time the circles were "bubbles" in the water. Andres explained,

> Um, where Mrs. Shamah was doing the experiment where she got the cup and the water and the heater was making it boil and lots of dew was going up to the pan and then I remember that I was a scientist because I was writing down information from here and I was trying to get it to my journal. So that kind of made me feel like if I was a scientist…I was writing what was happening and observing.

Even though his teacher, Mrs. Shamah, was "doing the experiment," Andres felt he was a scientist because he was "writing down information from here and I was trying to get it to my journal." Like in the MID, it was the act of observing phenomena and recording that made Andres "kind of…feel like if I was a scientist." There is a shift in tone from the MID interview to this one. In the MID, Andres was a scientist. He had observed water droplets go up from a puddle to form clouds. It was a fact with no modification. In the POST Andres modified his statements using fairly strong modalizations, "kind of" "feel" and "if," to explain

why he chose to depict this particular scene. Andres's developing conceptualizations of scientific practices and the kinds of people who engaged in them may have led him to recognize that what he was doing was similar to what scientists do. For Andres, he was not a scientist in the strictest sense of the word, but acted as one, at least for the purposes of our interview. Maybe, the material processes held for Andres more significance over textual processes in the practice of science. Since he was not the one actually involved in the manipulations during the hands-on exploration, and was only recoding his observations, the modalizations were needed.

In the second picture, Andres drew himself doing the take home-project from the *Forest* unit–"I remember when Ms. Shamah gave us a plant and soil so that way we could plant and we had to write a book about it…what's happening and things and then I remember that that's how scientists do. They first start observing and see what's happening then they write a book so that way other people could see what's happening." Again, Andres drew attention to observing "what's happening" and writing about the natural world for the information of others. "That's how scientists do. They first start observing and see what's happening, then they write a book so that way other people could see what's happening." The processes that Andres associated with being a scientist in both the MID and POST, observing and writing down those observations, were ones that his teacher had intentionally, explicitly, and repeatedly, associated with the behaviors of scientists. For instance, in March, as students were observing lima bean seeds, Andres's teacher, Ms. Shamah, mentioned scientists to direct student focus and behavior. Ms. Shamah walked up to Lorenzo, "What do you see? You're scientists." She turned to the class, "Remember you're observing. You're scientists. Third grade scientists who are making sure that they record every little detail they see" (Tucker-Raymond & Keblawe-Shamah, 2007).

In both pictures, Andres said the purpose of the science activities was to teach others about the topic. For Andres, scientists create knowledge that they make available to others. About his top picture in Fig. 3 he said, "So other people could learn about different things that you know so that way other people won't just stay in their house they could actually go to the library and see the books that other people made for them so they could learn more." For his bottom picture, Andres directly referenced plants and plant care–"So that way people could learn about plants like if they want to plant the plant that I planted they know what time is it gonna happen and so I made an example for them just in case anything happens to not do it to the plant."

In both POST pictures, Andres represented scientists learning information about the world, writing it down in journals and books, and sharing it with others at places like the library. Andres, in his stories about himself as a scientist, was exploring the world inductively, developing knowledge about it, and producing it for others. Even in his simple pictures, Andres represented science as a multifaceted and complex activity in which he took part.

DISCUSSION

Identity stories are inextricable from the activity systems in which they are produced. The activity system of the ISLE curriculum and approach valued certain scientific practices and identities. Thus, over time, the young children in this study told stories of themselves as scientists that were their recontextualizations of what they had learned about what was called "science" by the adult teachers and ISLE researchers, as well as their experiences with "science" and "scientists" in other activities of their lives (Tucker-Raymond & Keblawe-Shamah, 2007). Students' identity stories reflected their experiences in their classes during that year. The more students participated in ISLE, the more they rendered science as about finding out answers to questions, developing knowledge, testing hypotheses, and sharing and discussing science with others, rather than building machines or finding solutions to problems. Certainly, scientific practice encompasses various goals and approaches, and we do not argue that the ISLE emphases are the only ones that are suitable for young students. With this study, though, we show how ideological stances behind classroom curricula and experiences are central in students' identity building.

Moreover, our findings show young children who can and do conceptualize science as a complex activity with multiple purposes that includes multiple forms of practice. This positive identification with, and valorization of, science by students from groups historically underrepresented in science is particularly important. Students were more able to think about and represent themselves as scientists after having participated in just one unit of the ISLE curriculum, in part because their sense of science was not only sharpened, but also expanded through concrete examples of their own participation in scientific activity. This finding is consistent with DAST studies showing that treatments generally change students' perceptions of scientists (Finson, 2002). However, it goes beyond, in that it does not examine the effect of "treatments" that are separate from the actual teaching and learning classroom practices, but rather sheds light on how school science may change students' ways in which they identify themselves with science and scientists (Tucker-Raymond, Varelas, & Pappas, 2007).

Almost all of the statistically significant differences, revealed in terms of the categories we coded for, were due to whether the BAS interview was administered PRE, MID, or POST. There were no differences due to race and ethnicity, gender, or for the most part, grade. Thus, any differences were due to the children's own subjective experiences in the world and in the classrooms they were schooled in during the year of the study. That is, how teachers and students enacted ISLE differentially in classrooms over time had more effect than anything beyond individual differences. In this way, our findings support Wortham's (2006) notion of locally emerging models of identity formed and enacted in micro-systems of classrooms, schools, and communities.

While such differences point to particular aspects of the ISLE curriculum that may or may not have been particularly salient for students, the case study of Andres showed how students articulated nuanced, subjective experiences. The fact that many students did see themselves as scientists and that there were no

differences between gender or race and ethnicity counters previous claims that female and minority students, at least in primary grades, have "poorer self-images" than males and European Americans when it comes to who can be a scientist (Finson, 2002). Likewise, over time, students more often drew and talked about science as a social activity. That is, they were more likely to include other people in their pictures the longer they participated in the ISLE curriculum. Students were more likely to talk about themselves and others when they were asked questions about their pictures than they were to voluntarily draw themselves or others. Tests that just ask students to draw one scientist cannot accurately examine students' views of science as a social activity. Moreover, in asking the question differently than other DAST studies, we explicitly opened up possibilities for students to conceive of themselves as scientists. Finally, by asking students to draw themselves, and not others, as scientists, our study opens up methodological considerations for investigating students' conceptualizations of themselves as scientists–a major goal of national initiatives for learning science in formal and informal settings (Bell, Lewenstein, Shouse, & Feder, 2009).

NOTE

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7. MEANINGS OF SUCCESS IN SCIENCE

In this discussion of the five chapters in *Part 1: K-12 Science Learners In and Out of Schools* of this book, I will take the cue from Carlone's chapter and ask a set of questions about the research projects that provide a somewhat different lens for viewing the cases than taken by the authors themselves. Carlone argues that our research often describes the ways in which students are authoring their own identity in ways that do not account for how student identities are constrained by social structures that are both historical and temporal. Different contexts may define what it means to engage successfully in science in different ways. We know that engaging in science at home, in community settings, in school, and in professional settings varies in terms of what counts as success in those settings (National Research Council, 2009). Our research should also interrogate the variety of ways in which apparently similar settings may in fact offer very different definitions of success in science. At the same time, we should include in our analyses the ways in which success in science may be defined in similar ways across contexts. This is especially pertinent in understanding how students are marginalized from science. Thus she argues for asking the questions, "*Who are students obligated to be in this setting*? *What does it mean to be successful? What opportunities does the setting provide for individuals to be successful?"*

Two of the authors of these chapters examine science identity primarily in the context of after-school programs (Rahm & Gonsalves; Guerra, Barton, Tan, Kang & Brecklin); the other two study identity in reformed elementary science classrooms (Kane; Tucker-Raymond, Varelas, Pappas, Thiede, & Keblawe-Shamah). All of the chapters also attempt to account for how the children and youth engage in science with family and friends. The school curriculum and after-school programs have been designed with the engagement of minority youth in mind. This does not mean, however, that the contexts were designed without significant constraints. The school curriculum is constrained by the fact that it must meet state standards and expectations in a public system. After-school programs, on the other hand, must be sufficiently desirable for youth to choose to participate in them. They are constrained also by expectations of funding agencies supporting the programs financially, as described in Rahm and Gonsalves' chapter. Nevertheless, the authors of these chapters are engaged in both designing contexts in which children and youth can successfully engage in science as well as studying how children and youth position themselves, and are positioned by others, in these contexts. I will discuss the work of these authors and the students with whom they work in the context of school, after-school programs, and home.

M. Varelas (Ed.), Identity Construction and Science Education Research: Learning, Teaching, and Being in Multiple Contexts, 97–101.

WHO ARE CHILDREN/YOUTH OBLIGATED TO BE IN SCHOOL SCIENCE? WHAT DOES IT MEAN TO BE SUCCESSFUL IN SCHOOL SCIENCE?

In many schools, science classroom practices are complicit in the reproduction of a scientific elite that privileges the participation of some students over others–a pattern that manifests itself along ethnic, racial, and socioeconomic lines. This is done in part by tracking and patterns of course taking that literally sort students into classrooms that either provide access to high status science instruction or assure that they will not have access to rigorous science instruction. However, long before students are sorted out of science, norms and routines for doing science are experienced by learners in ways that have mostly negative outcomes for students from non-dominant groups. Some researchers have argued that the problem is that science classroom practices are discontinuous with the knowledge and experiences that children from non-dominant backgrounds bring with them from their home communities (Warren, Ballenger, Ogonowski, Rosebery & Hudicourt-Barnes, 2001). While I do not disagree, I would argue that many of the norms and routines in science classrooms are not continuous with any set of practices in any setting outside of school. Commonplace practices in school science are not common in homes or communities regardless of ethnicity or social class nor do they synchronize well with professional scientific settings. Reba Page (1999) has documented how high school science in a very affluent area of California included very little in the science curriculum that was recognizably scientific. There is a "schoolishness" about many of the practices of school science that simply do not map onto any other practices in communities outside school.

Typical school science classrooms obligate students to engage in activities such as reading the textbook, answering questions asked by a textbook author or by the teacher, carrying out routine laboratory investigations with known answers, and engaging in classroom talk that is initiated by the teacher. Being successful is achieved by following directions and being recognized for having correct answers. In other words, Carlone's description of Mrs. Sparrow's classroom is commonly found throughout the literature.

Although descriptions of the classrooms of the students in the studies by Guerra et al. and Rahm and Gonsalves were not a part of the data corpus, the girls' references to school science classrooms were not positive. While they understand the importance of being successful in science for their career aspirations, this was not enough for them to fully engage in the activities in the science classroom. In the case of Kay in Guerra et al.'s chapter, her inability to attend school on a regular basis due to her challenges at home, made it impossible for her to be successful in school.

The chapters by Kane and Tucker-Raymond et al. highlight individuals who are still in elementary school and engaged in a curriculum that integrates science and literacy. Unlike most science classrooms, in this setting, students were obligated to work collaboratively with their peers and the teacher to "draw, talk, share, write, think, and do science" (Kane, p. X). Kenny is successful in this setting by being a good thinker and for volunteering extensive information on topics he cares about. As he puts it, "[My classmates and teacher] thought of me as a thinker…[because]

I'm really good at working and really good at listening…they thought of me as a smart person because I knew a lot about dinosaurs."

The chapter by Tucker-Raymond et al. draws on the same project as that by Kane. However, the context of the data collection was a specific task in which the children were asked to draw two instances in which they acted like scientists. While this question does not directly ask about the activities in science class, the children nevertheless draw upon those experiences in responding to the interviewer. The children's drawings illustrate their view that being successful meant participating in practices like scientists, such as writing down detailed observations, and communicating what they have learned to other scientists. The practices depicted in the children's drawings and in their interviews about the drawings were heavily influenced by a science curriculum that valued certain scientific practices and identities. What is important is that the children took on the scientific identities valued by the curriculum.

WHO ARE CHILDREN/YOUTH OBLIGATED TO BE IN AFTER-SCHOOL PROGRAMS? WHAT DOES IT MEAN TO BE SUCCESSFUL IN THESE AFTER-SCHOOL PROGRAMS?

An after-school program is another site where some students have the opportunity to engage in scientific practices. Since they are not constrained by the demands of standards and assessments, there is more flexibility in how researchers can create opportunities for science learning that are more closely aligned to activities that are of interest to children and youth, and to the skills and dispositions they bring from their home communities. Thus, Guerra et al. have designed an after-school program for youth to engage in scientific issues of direct relevance to the communities in which they live, and to leverage their capabilities and participation in youth culture to shape the scientific activity in ways that are personally and culturally meaningful. The youth engage in learning about Urban Heat Islands by listening to scientific experts, as well as by gathering information from their friends and families who live in urban communities and thus have relevant knowledge and expertise. They then author multimodal artifacts that are used to communicate the need for change to others in their community, as well as to experts who may not be a part of their community.

The definitions of success in this program are radically different than the definitions of success in a traditional school setting. For example, being committed to making a difference in your community is a core value of the program. In this paper, Kay's desire to improve her community drives her activity and participation in Green Club, and brings her to the attention of the authors as an important success story. Whereas school science most typically values the acquisition of knowledge, this after-school program places premium value on the use of knowledge. It is perhaps not surprising that it is quite possible for a young person such as Kay to be a failure in one setting and a success in the other.

In Rahm and Gonsalves' chapter, the after-school program activity is a science newsletter. The obligations of the students and their leaders are to produce a newsletter for elementary-aged children, which is scientific in its content. The

program leaders must respond to the requirements of their sponsors, and thus the artifact is quite important. When Kassandra pushed the boundaries of what counted as science by writing a science-related poem, she effectively expanded the definition of what counted as success in this particular setting.

In neither of these cases did the girls' participation in the after-school program lead to stronger participation in school science. Perhaps the activities, goals and measures of success across the two settings are too different for the competencies gained in one site to be used to leverage success in the other. While there is tremendous value to being successful in after-school programs, there is also value in excelling in school science because of its credentialing function and the access it provides to social mobility.

WHO ARE CHILDREN/YOUTH OBLIGATED TO BE AT HOME? WHAT DOES IT MEAN TO BE SUCCESSFUL AT HOME?

All learning begins at home, and science is no exception. The degree and nature of science learned at home, however, varies not only be culture and socioeconomic status, but also by individual family (Brickhouse & Potter, 2001). In other words, one cannot necessarily predict the extent to which a family may be supportive of science learning based on demographics alone.

In these studies, there is one theme that holds across all the cases. The children come from families that value education and understand its role in providing social mobility for their children. In some cases the stressful conditions under which these families live make it difficult for their child to be successful in school, but in none of the cases do the families undervalue the importance of school.

The cases of Kay (in Guerra et al.'s chapter) and Kenny (in Kane's chapter) provide the strongest cases of families where there are strong role models for the children. These families clearly have high expectations for their children and are emotionally supportive of them. However, there is little evidence that these families are providing access to the skills, dispositions, and resources that children and youth might use to learn what they need to know to be recognized by others as "scientific." In my own research (Brickhouse & Potter, 2001), I traced the routes to success in science of two minority girls. One of these girls lived in a low-income community in the city with her mom. As much as this mother loved her daughter and wanted her to excel in science, she had little to offer in terms of access to science because neither she nor others in her community knew how to help her daughter when she encountered academic challenges in school science/technology. This case stood in stark contrast to another girl, Ruby, who came from a low income home, yet her father had very advanced technical knowledge and surrounded his daughter with the material and intellectual resources she needed to learn computing. In the first case, the girl was obligated to be a good student in school, and she was; in the latter case, the girl was obligated to understand computers, and she met those expectations as well.

In these cases it is clear that the families very much wanted the girls to be successful in school. However, they are *obligated* to be loyal to their families and

communities. For example, Kenny is a Smallwood. With this comes an identity as being part of a family with a certain set of values: hard working, well behaved, and successful. These were both how Kenny described himself as well as a set of expectations others had for him.

SUMMARY

The strength of this selection of chapters is that the studies account for how individuals engage in science in a variety of settings and in some cases, over several years. This is critical to understanding the development of identity in science. Equally important is understanding the constraints on identity development in these settings. Children/youth are never truly free to be whatever they wish. The expectations and obligations placed on them by societal structures that are both historical and temporal in nature play a powerful role in shaping the scientific identities of children/youth.

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PART 2: TEACHERS AND PRACTITIONERS OF SCIENCE

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8. POSITIONAL IDENTITY AS A LENS FOR CONNECTING ELEMENTARY PRESERVICE TEACHERS TO TEACHING IN URBAN CLASSROOMS

INTRODUCTION

Using qualitative methods of data collection and analysis, this study explores positional identity as a lens for understanding elementary preservice teachers' discourse around identity and science teaching. The three preservice teachers in the study were enrolled in a 16-week science methods course. At the conclusion of the course, they agreed to participate in this study to explore early understandings of positional identity and science teaching. The findings suggest that positional identity is a useful lens for understanding the complex ways in which preservice teachers discuss who they are, and how they view self and teaching. Their views of self can be used in developing stronger relationships to science, to teaching science in urban classrooms, and for developing relationships with students in urban classrooms.

EXPLORING DEFINITIONS OF IDENTITY

Identity, though fascinating, is a complicated and challenging construct in educational research, as many researchers discuss and interpret "identity" in various ways. For instance, identity definitions span the gamut from discursive identity (Brown, 2004), gendered identity (Carlone, 2004) and racial and ethnic identity (Chavez & Guido-DiBrito, 1999) to subject matter identity, such as scientific, mathematical or linguistic, for both teachers and students (Cobb, 2004; Kozoll & Osborne, 2004; Spillane, 2000), as well as teacher identity (Franzak, 2002), teaching identity (Agee, 2004), and teacher professional identity (Abell, 2000; Beijaard, Meijer, & Verloop, 2004). These various definitions of identity encompass a range of interpretations as researchers have drawn from a number of different disciplines to construct meanings of identity.

Furthermore, researchers discuss the complex and dynamic nature of identity. For example, "identity is a constant social negotiation that can never be permanently settled or fixed, occurring as it necessarily does, within the irreconcilable contradictions of situational and historical constraints" (Britzman, 1992, p. 42). Similarly, identity is the "kind of person one is recognized as being, at a given time and place" and "can change from moment to moment in the interaction, can change from context to context, and of course, can be ambiguous

M. Varelas (Ed.), Identity Construction and Science Education Research: Learning, Teaching, and Being in Multiple Contexts, 105–121.

or unstable" (Gee, 2002, p. 99). Finally, Wenger (1998) defines identity in relationship to social structures, such that identity is constructed within communities of practice in the development of who we are as individuals. In constructing who we are as individuals, the social negotiations, interactions, and experiences with others frame who we are, how others see us, and how we want to be seen by others. Moreover, Beijaard (1995) defines identity as "who or what someone is, the various meanings someone can attach to oneself or the meanings attributed to oneself by others" (p. 282). He relates this to teachers' professional identity and expands the discussion of professional identity to include three distinctive categories: the subject one teaches, the relationship with students, and the teacher's role or role conception.

Identity through Positionality

Many researchers, such as those referred to in the previous section, use definitions of identity with little or no discussion of how race, class, gender, and other social markers intersect and interconnect in the development of identity and their interactions with students. Missing is an analysis of positionality. Using a feminist poststructural framework (St. Pierre, 2000), positionality is fundamental to understanding how particular social variables intersect with teacher identity. Tetreault (1993) explains that positionality, for example our gender, our race, our class, and our age are "relational positions rather than essential qualities" and that "their effects and implications change according to context" (p. 139). Given background factors such as race, class, and gender, positionality refers to how one is socially located (or positioned) in relation to others (Maher & Tetreault, 1994). Without a consideration of these factors, understanding identity becomes separated from the sociocultural, sociohistorical and sociopolitical dimensions of who a person is, how a person chooses to define self, and eventually how the person teaches. The sociocultural, sociohistorical and sociopolitical dimensions reveal interactions within social contexts, such as schools, and power relationships found in these contexts. Together these shape which identities are constructed, how they are constructed, and why particular identities are taken up within certain social contexts over time.

In previous work on positional identity, I note the intersection of multiple social markers for three African American secondary science teachers (Moore, 2008a). Their positional identity influenced how and why they taught science and shaped the relationships they developed with their students, and even how students perceived them in the classroom. I explain further the relationship between positional identity and science teaching and argue for new models of teacher professional development that consider personal history and positionality of teachers.

Building on that work, this case study employs positional identity as an analytic lens. Positional identity is operationally defined in terms of multiple social markers (i.e., race, ethnicity, economic status, gender, religion, and age) and how views of self through these social markers influence the ways in which preservice teachers

talk about teaching and science teacher identities. They self-identify and discuss social markers that are most proximal, or forefront in their view of self, or their identity, namely, *who they are*. These views of self can be used in developing stronger relationships to science, to teaching science in urban classrooms, and to developing relationships with students in urban classrooms. The research questions for this study are: To what extend does positionality influence the construction of a science teacher identity for elementary preservice teachers? How do preservice teachers discuss their positional identities, or the intersection of social markers most proximal to their identities of self and teaching?

METHODS

Setting and Participants

This study took place in a large urban northeastern university. Three preservice teachers in teacher education (Junai, Rose, and Monroe) had enrolled in a 16-week elementary science methods course and consented to participate in this study. They were also participants in a larger research study (Moore, 2008b). However, these three were selected for this study of teacher positionality because of similarities and differences in their past experiences as science teachers, their construction of a science teacher identity, and their experiences in the methods course. Junai (Asian American) had no prior teaching experiences in science and was a product of an urban school education in New York City (NYC); Rose (White) had some teaching experiences, albeit in the form of substitute teaching in a science classroom prior to the course. She was from a suburban background and was raised on the west coast. Finally, Monroe (Korean American) was interested in teaching grades 5–6 and was a former fifth grade science teacher with a provisional certificate. As a course requirement, all of the preservice teachers had to plan and teach a science lesson, either in the university classroom or in an urban elementary classroom where they were placed during the semester. Due to employment constraints, Junai elected to teach in the university classroom, and Rose and Monroe taught in an urban elementary classroom.

The three were also selected because they shared a desire to teach young learners and to be influential in making a difference in the lives of young people. Still, the ways in which they talked about their identities and backgrounds (in-class discussions and written course assignments) proved to be quite interesting to study. My curiosity in understanding science teacher identity through positionality made them likely candidates to explore this issue.

Data Sources

A qualitative case study methodology was used for this study (Creswell, 2007). Case study is described as "a bounded system (a *case*) or multiple bounded systems (cases) over time, through detailed, in-depth collection involving *multiple sources of information*" and "reports a case *description* and case-based themes" (p. 73, emphasis in original). This form of research is in "search for meaning and

understanding" with "the researcher as the primary instrument of data collection and analysis" and the "end product being richly descriptive" (Merriam, 2009, p. 39). A limitation of case method is that the findings are not generalizable; however, readers of the case are able to transfer themes from the study to their particular situation. Thus "qualitative case study is valued for its ability to capture complex action, perception, and interpretation" and to "feed into the naturalistic generalizations of readers and writers" (Stake, 2007, p. 3). Several data sources were collected and analyzed in order to present the case studies of Junai, Rose, and Monroe.

Interviews as conversations. Because the three preservice teachers were former students in an elementary science methods course, I had built a rapport with them over the semester. The interviews as conversations were appropriate for eliciting their ideas, personal meanings, and understandings about positionality and the construction of a science teacher identity. At the end of the semester, I invited them to participate in this study. With consent, each preservice teacher participated in a digitally recorded interview as conversation that lasted approximately 55–80 minutes and consisted of both semi-structured and open-ended questions. The open, conversational format allowed for in-depth probing of personal experiences. For example, we discussed their learning from the methods course and teaching science. The preservice teachers also drew images of the ideal elementary science teacher as a pre-drawing (first day of class) and post-drawing (last day of class), which they discussed during the interview (Mensah, 2011). The conversations also focused on science teaching, past experiences as learners of science, and teaching students of diverse cultural backgrounds.

Card sort activity for positionality. I wanted to engage participants in thinking about the interconnection and intersection of multiple social variables within subject-matter specific domains in order to understand identity and teaching. Research methods that allow participants to make meaning of multiple social variables and life experiences in order to inquire about teaching may generate deeper understandings of positionality and teaching. Therefore, for this study, a Card Sort Activity was developed where the preservice teachers were asked to discuss their positionality and teaching. During the interview, Junai, Rose, and Monroe were given twelve small (2 × 2) index cards with the words "Religion", "Class/Socioeconomic status", "Gender", "Political affiliation", "Race", "Ethnicity", "Upbringing (urban, suburban, rural, regional)", "Sexual orientation", "Disability/Special need", "Age", "Education", and "Language" written on them (Figure 1). They were instructed to put the cards in whatever order they like, but to put the "card or cards that you identify with the most, those most proximal to you or your identity, put those cards closest to you." They were asked to talk through the sorting of the cards, which was part of the interview (recorded and transcribed). Though presented with the cards, the nature of self-selecting social markers (i.e., those social markers most proximal in describing oneself as a person) revealed the preservice teacher's perceived self in relation to the world. The top three

self-selected social markers were then used to frame the remainder of the conversation. Junai, Rose, and Monroe explained how their selected social markers were influential in their identity, or *who they are*, and how these variables intersected in their understanding of self, science, and teaching.

Religion	Class/ socioeconomic status	Gender
Race	Ethnicity	Upbringing (urban, suburban, rural, regional)
Disability/ special need	Age	Education
Political affiliation	Sexual orientation	Language

Figure 1. Card Sort Activity.

Other Sources. As part of the course, the preservice teachers completed pre-surveys (regarding demographic information, views of teaching, and experiences in teaching) and post-surveys (regarding reflections on the course, views of teaching science, and teaching in urban schools). Written assignments from the course were also collected (reflection papers, drawings, lesson plans, final papers). As the instructor and researcher of the course, I kept a reflective journal. The journal contained observations of microteaching lessons done in the university and elementary classrooms. It also contained notes from the course and informal conversations with the preservice teachers. These other sources provided contextual information for adding to and discussing the preservice teachers' backgrounds, teaching, and learning over the semester.

Data Analysis

The conversations, as well as written assignments, were transcribed and coded using methods of constructivist grounded theory (Charmaz, 2006). Coding was initiated by reading and re-reading the data several times in order to get an overall sense and general understanding of the data. After this, the two-stage process of analytic coding described by Charmaz was initiated. Sticking closely to the data, and allowing the codes to emerge during the first stage of initial coding, led to the creation of a large number of codes. This was important in order to prepare for focused coding, where "the most significant and/or frequent earlier codes" (p. 57) were used to categorize, compare, and continue the process of data analysis and interpretation. For example, several codes emerged from the analysis of the data

around teacher identity and science teacher identity, and additional broad categories from the Card Sort Activity, such as perceptions of science and science teaching, concerns for teaching science in urban classrooms, and views of identity. The preservice teachers discussed different social markers that they perceived to be proximal to their identity. The priority they gave to describing their experiences in the selection of particular social markers were discussed in greater detail. The positionality lens made it possible to reveal both explicit and implicit meanings the preservice teachers associated with self and teaching.

As the researcher, I viewed the analytical process of using positional identity as both an individual and collective process (Moore, 2008a). For example, I looked for similarities and differences in experiences of the three preservice teachers. It was challenging to frame their cases around similar themes, and perhaps this has to do with analyzing a small number of participants and their differing life histories and unique experiences. However, the few similarities and differences have important implications for understanding how elementary preservice teachers perceive self in relationship to others, science, and teaching. Through member checks (Guba & Lincoln, 1989), the preservice teachers responded to interpretations during and after the interview. Finally, prolonged engagement and comments from two science education peers, who read drafts of the interpretations and offered comments, were additional methods of strengthening the study's validity (Guba & Lincoln, 1989).

FINDINGS

This case study reports findings from conversations with three elementary preservice teachers about positional identity, teacher identity, and subject-matter identity. First, I give background information and views of science as a means of introducing the three teachers. Second, I present information from the Card Sort Activity–the three social markers most proximal to their identity–and discuss each preservice teacher and offer insights into their views of self and teaching. Finally, I discuss how these views of *who they are* can be used in developing stronger relationships to science, teaching science in urban classrooms, and developing relationships with urban school learners.

Teacher Backgrounds

Junai's Background. Junai, 24 years old, is an Asian American female who was "born and raised in New York, the capital of the world." She has a strong affiliation to the urban lifestyle because she is a "product of the NYC public school system, the Staten Island version." Junai loves that there is so much to do in the city because "it never gets dull" and there are "always new things, always change", and she loves walking around the city. Junai has a fun and energetic personality. She was very open in discussing with me her experiences in learning science as a young student. Actually, she did not like science in high school because of the "very didactic, very test-based" approach of many of her high level science

courses. Junai commented, "It was a lot of pressure as well to just take these courses [that] were assigned. We didn't have any options. Like freshman year, I had to take biology and chemistry at the same time, so that by junior year I can take AP [Advanced Placement] physics and AP chemistry. So it was just a fast track and it wasn't for me." Junai stated that in order to learn science she had to do "a lot of memorization…for [her] it was pure memorization." Junai admitted that the fast track of high school science and not liking it were actually the impetus for thinking about teaching:

> I'll give you a fun fact: I was in the Science Institute in high school, so we were like tracked and pushed into taking a lot of science courses–AP bio[logy], AP physics, and science, and then I discovered I really didn't like science out of that! Which was good in some ways because then I decided, you know, I want to become a teacher eventually. But I felt at that point, I wasn't learning science I mean, certain things interest me, I think like physics interests me a little bit, but not chemistry and biology.

Although Junai had an interest in becoming a teacher, prior to taking the science methods course, she had never taught science and had "never actually officially stepped inside of a classroom." But she wanted to be a teacher, unfortunately, not a science teacher.

Rose's Background. Rose is a White American female, age 26. She grew up on the west coast of the USA. Similar to Junai, Rose has a fun and energetic personality with a girlish-type laugh that resounded throughout the semester and during the interview. Rose was very open about sharing her educational history. At the end of middle school when selecting classes for high school, she went to the school guidance counselor for advice on which classes to take. Since she was in the college preparatory track, she was expected to take higher level science classes, but she told the guidance counselor that she wanted to take "regular science instead of the honors and AP science classes because she did not like science." She cannot recall from grades 6–8 the reason for not liking science; however, she remembered having male science teachers and laboratory instructors. Her male teachers were stern and did not allow students to talk. She wondered how could students not talk yet still be expected to learn the science. In this learning environment, Rose could not connect to the science and did not enjoy learning it. She described high school science as being "very textbooky" with "a lot of labs." She commented, "I didn't pursue science after high school really." In college, she took one science class, which was a genetics course that was very basic, and students jokingly called it "*Genes for Teens*." The class was "interesting because it sort of related genetics to everyday life," but Rose replied that "we didn't do anything beyond like eighth or ninth grade genetics like on the college level." Rose also described that science learning was not about learning from mistakes or answering questions to gain a better understanding of the phenomena. It was simply completing confirmation labs where Rose felt like

there was no wondering, thinking, discovering, or any attempts to really understand the science or the phenomena:

> But yeah, I think just as a student, it was very much like this is the phenomenon you're supposed to see, and if you don't see it, then you did something wrong [laughs]. As opposed to if you don't see it, okay, well, what happened and why? I don't recall it ever, I mean, I'm sure I had teachers along the way that were explaining or getting us to understand why it was happening, but I didn't feel like I was ever discovering anything myself.

Rose expressed that it was not the science content that turned her off to science. It was probably the series of "not real super science classes" and "specific teachers" that made school science not interesting and exciting.

Monroe's Background. Monroe is a bilingual Korean American, who grew up in California. He speaks Korean to his parents at home and in church, and speaks English "everywhere else." Monroe loves languages and had taken French in high school and in college a Spanish class and an intensive Chinese class. Monroe was interested in teaching grades 5–6, and was a former elementary teacher for two years in Washington, DC. The school was "highly urban, [in an] under-resourced neighborhood, with ninety-two percent African American, six percent Hispanic, and one Chinese American student." During the interview, and often in informal conversations, Monroe spoke about missing teaching. He mentioned that the principal of his old school was holding a 6th grade teaching position for him when he completed his graduate education. He said, "the idea of being a teacher, being a role model, a figure, I enjoy that role. I love it. That's why I'm coming back to it because I miss it. I miss the direct interaction with the kids." Monroe had not completed student teaching but had planned to do so the following semester. He worked with the Reading Buddies program, which required him "to observe and interact with students in an urban classroom for 2–3 hours a day, three days a week." Though Monroe had prior experiences teaching as a full-time teacher in Washington, DC, he did not have an extensive science teaching background. However, he stated that he felt "pretty comfortable with science" because it was something that he had studied on his own for as long as he could remember, or since he was "very young."

Now that the teachers have been introduced, in the next section, I discuss positional identity, the social markers most proximal to the three teachers' identity, and their views of teaching, science, and students.

Positional Identity and Teaching

Junai–upbringing (urban), race/ethnicity, and religion. Because Junai grew up in NYC (upbringing/urban), she wanted to teach in urban schools. Part of her desire to do so was to affirm her own cultural identity, being from an immigrant family. Her parents came to the US as young adults, but she was the first generation to

attend college. Junai wanted to support other immigrant students in making the challenging transition from home culture to the culture of school and the American culture:

> Particularly I like to teach in immigrant communities because I come from an immigrant family and that's my background, and so I feel like New York is a place that just has a wide range of immigrants, and I feel like it's critical almost because these are going to be the leaders of the future in the city–in our city particularly. So I think investing in immigrant communities, and to ease that transition and to help, at the same time.

Junai felt strongly about being a teacher and identifying with immigrant students. She explained, "I think that a lot of times I struggle with, you know, having two cultures and, you know, going back and forth between them, and I think it's important for students to be affirmed in the culture of their homeland as well as their American culture, and so I think that's kind of why I want to do immigrants."

Junai discussed that it was "important to identify similarities and differences within the two cultures"–being Asian and American–that framed her identity as well as the purpose for why she wanted to be a teacher and whom she wanted to teach. She said, "Like there's no way, I mean, there's no formula to be like an Asian American. It's kind of, you know, I feel like I kind of go back and forth between the lines, and if there is a line, or I'm just defining that as I go along." Junai considered both the advantages and disadvantages of being Asian and American in framing her identity, first being influenced by her parents' Asian culture and growing up in the American culture:

> So I think just being aware, self-aware of background, of my family as well as just the things that are often in conflict because that tends to be where the conflict is, things that are different from my parents' culture and then learning to see, you know, the positives and negatives of both.

Religion also played an important role in Junai's identity and personal life. While growing up, religion was not a part of her early life, but in high school she started "going to church and that's where [she] really discovered spirituality and God." She commented that spirituality was an "important decision" that she had made and wanted to make it a continual part of her life. When we discussed religion and science teaching, Junai did not see any connections between spirituality and science, yet she felt that her religious understandings and spirituality would influence her science teaching. Spirituality and science would provide different perspectives for her learning or her students' learning. She assessed that she needed to think about how to bring different perspectives into her classroom:

> I think part of that [the motivation and the joy of teaching science] has to do with my spirituality, and just understanding and kind of connecting that in my own head, and therefore that would give me more joy in teaching science…I feel like these things [upbringing/urban, race/ethnicity, religion] all bring different perspectives, and so I think they will definitely come out in how I [teach], so part of me needs to, I feel like, think about how to have

> different voices represented, or different perspectives represented in my classroom.

Through a positional identity lens, there were multiple influences on Junai's emerging identity as a science teacher. For example, Junai's three social markers most proximal to her identity were upbringing (urban), race/ethnicity, and religion. She believed her own experiences growing up in NYC, being an immigrant, as well as first generation college student, and being aware of her racial and ethnic background would make her a good science teacher. Junai stated that the reason she decided to go into teaching was because teaching was "actually a spiritual gift" that God entrusted to her. She acknowledged that, "God has definitely been an influence in that, so that's like part of the core of why [she's] in teaching." Junai explained that she wanted to use her "gift" to help other immigrant students. She commented, "then ethnically and geographically and I guess the race thing, I think that has to do with it too, like, actually they all kind of mush together, but I think these [upbringing (urban) and ethnicity] kind of have to deal with [being an] immigrant. The whole, you know, I wanna go and help the communities that are adjusting to being in America."

Rose–gender, age, race. Rose expressed that being a "White woman" defined her identity as a person. Identity was something that you "owned." Her race and gender were part of her identity, and these aspects could not change:

> Yeah, I mean, I think that, hmm, um (pause), your identity is something, something that you have a lot of ownership over. You don't have a lot of, you aren't necessarily able to control all the aspects of it [identity] 'cause unless something very real happens, I'm always going to be, you know, a white woman as a teacher. That's not something that I can, that I plan on changing [laughs].

Rose's identity was influenced by gender, age, and race, which were easily distinguishable if someone simply looked at her, stating, "…those are the ones that are sort of visible." Therefore, gender and age were equally important in defining her identity because, "yeah, gender and age, I think those are the two that I would, you know, describe if someone asked me about myself, I would say I'm a woman, I'm twenty-six. I think those are big [laughs]."

I questioned Rose more about her understanding of race, since this was her third selection and something she believed she could not change. She stated: "I think, I think race, it's not something I think about, but it's something that I recognize as significant in my life. I don't know how to say that more specifically, but, yeah." Rose shared that race had a large impact on her identity as a "White" woman but could not articulate to what extent it had an influence on her identity. She then explained how race was "bigger" or perhaps had a greater impact in her life than ethnicity because she was a White woman:

> Yeah, I decided to put ethnicity as different [from race] because I think I don't have, in terms of my ethnic background, there's no one big thing. I

> think I'm sort of enriched in a lot of the different Eastern European countries, that there's not one country or ethnic background that's really bigger than the other, so I think the biggest one's like Estonia, and I don't know anything about Estonia. Um, so I don't see ethnicity as a big part of either my self-definition or a big thing, you know those kinds of things. I mean, that's sort of a silly definition, but whereas race is, I think is bigger, because I mean, the reason I put race over ethnicity is because I'm White [laughs]. Anything more specific than that just doesn't make a big difference, at least it hasn't in my family background.

Similarly, Rose did not consider socioeconomic status as very important in constructing her identity; it was not one of her top three selections; however, she talked about socioeconomic status in the interview, as she narrowed down her selections. Rose was aware of how class afforded her opportunities and advantages in her life because she came from an "upper middle-class family." She stated, "Social class isn't something that I would need to identify myself, but I recognize it within a huge part of my general development in terms of like opportunities I've had and, you know, that sort of thing." Therefore, the social markers most proximal to Rose's identity were gender and age, though she recognized both race and socioeconomic status as granting her some privileges as a White woman.

As a science teacher, Rose considered that her gender would be very important for teaching pre-adolescents. Gender was one social marker that she felt was "explicit" and could be addressed in the classroom because she would be "aware of female students" in her classroom. She wanted to teach grades 4–5 because this was "where a lot of girls tend to start to shut down a little bit in terms of their education", and being a female teacher, she would be aware of the girls in the classroom and try to encourage them to "focus less on appearances and more on education." Rather than girls "making sure their hair looks nice is more important than whatever [laughs] we're reading that day or whatever is going on in class that day or, trying not to look too smart, I want to make sure that everyone in my class wants to look as smart as they possibly can! [laughs]." Through a positional identity lens, the multiple influences on Rose's emerging identity as a teacher were her being a young White woman and finding ways to connect to girls in the classroom.

Monroe–gender, race, and ethnicity. The talk-aloud procedure that Monroe engaged in while sorting his cards revealed his thinking and perceptions of how positionality was influential in his identity. Monroe, sorting out the cards, stated:

> …coming from a very middle-class background, I'm sure that has impact on how I think…Disability, special need, it doesn't really govern how I think about things. Geographic location/upbringing, I feel like being from California where the weather is like beautiful every day, of course has some impact, so I feel like it's very similar to social class because it's my upbringing. Political affiliation, I don't talk about politics very much so I can't really say it's important. So let me, religion perhaps. Age, uh, I don't

> think, in the way, so somewhere in the middle. So I feel like, so I guess this would be things that I can't change, um race, ethnicity, gender. Things that I also have and been able to change, social class, geographic location. And things that are more or less my um, my, that impact, that have been my choice: religion, political affiliation. Age, I feel like it's a choice because I can choose to act my age or younger if I want to. Sexual orientation and disability, I feel like they're non-factors. Race and ethnicity, I guess I see in a very similar view or light as important, and religion is important to me but it doesn't quite define how I'm known to the world. Sexual orientation, I feel like that doesn't necessarily make too much of an impact in my life.

Monroe finally selected gender, race, and ethnicity as the social markers most proximal to his identity. Because Monroe had more teaching experience than Junai or Rose, he revealed some connections to science learning, teaching, and students regarding his three selections. Monroe first identified gender as most proximal to his identity, and this was because "here, just at [The College], gender is important because I am one of three males" in the science methods course. He also added, "gender made or played a strong role" when he was teaching, largely because "there are not that many male figures in elementary schools." Because he was one of three males in the school building and was the only male elementary teacher (the other two were middle school teachers), Monroe felt that his students responded very positively toward him because he was male, "a male authority figure that they haven't had much experience with."

Monroe "purposefully" and "purposely" acted in ways that showed that he was aware of his positionality, which influenced the decisions he made for his education. For example, though he enjoyed science as a young student, he decided not to major in science or mathematics because of his positionality. He explained that he "purposefully veered away from science particularly in college" because he "did not want to follow the same, shall we say, ethnic identity track of math and science for a lot of the Asian American community." Instead, he wanted to "branch out" and identify his areas of interest. In making this choice, he "purposely did not take science-oriented classes, with the exception of what was required to graduate." Although he did not major in science in college, science was always "an interest" in his life and he felt "pretty comfortable having conversations" and "can talk about most areas, like technology and what's going on there."

Furthermore, Monroe discussed Asian American stereotypes as a way to understand his positionality and relationships with students. He discussed the impact of the "smart" Asian American stereotype for him, and the advantages that his Asian American background had in the classroom. He said that "to a certain degree race and ethnicity as an Asian American kind of plays it both ways." He explained:

> Because of the fact that I am, I know that in my classroom, my race and ethnicity was [a major factor]. I had a conversation with kids [who believed] my race and ethnicity is a second thought. 'It's Mr. Monroe. He was Asian, that's right'…maybe because I was Asian, I think my students trusted my

> judgment better. I think it's kind of a double-edged sword of the race stereotype coming into play, where Asian Americans are viewed as good in math and science, playing musical instruments, whatever it may be, and that being the case that kind of feeds into the idea about, oh, these Asian Americans, it must be true because he's smart.

Monroe also discussed the Asian American stereotype in terms of expectations for a career choice. He remarked, "For every other professional field, Asian Americans are very public. Law, medicine, science, engineering, a variety of other fields, largely because I feel like there's a lot of societal, Asian American community pressure to be quote-unquote 'successful' in your professional career. And successful, success in a professional career usually means making lots of money, and of course, teaching is not part of it." Monroe felt that he placed himself in an "interesting position" whereby he "picked a field that bucks the trend." Finally, Monroe stated, "Perhaps I revel in the idea of creating my own niche identity…how I come to this career choice" of teaching.

Therefore, Monroe discussed gender, race, and ethnicity as the social markers most proximal to his identity. Being a male Asian American, he cited the "smart Asian American stereotype" or what Lee (1994) calls the "model minority stereotype" to discuss his positionality and relationships to students. His positional identity also shaped career choice because he did not want to succumb to the smart Asian American male stereotype. However, Monroe gave an explanation of how his gender, race, and ethnicity can work to his advantage, especially to reach students:

> I feel that the vast majority of people who draw on math and science are male, and I think to have the idea that, oh, it's a male-dominated field; therefore, he must know something about science. I feel it's a negative and a positive stereotype that I feel like I've been able to use to accomplish what I need to accomplish. I don't think anybody is really above the idea of using your racial stereotype to your advantage, especially if it means reaching kids and having them learn something. I'm not too sure that I'm comfortable with the idea, but when your toolbox is limited, you've gotta do what you gotta do [laughs].

Using the smart Asian American stereotype, Monroe provided an alternative interpretation and reason for what he does and how he may be effective as a science teacher. He took this view to counter a negative stereotype to help his students. Therefore, Cooper (2005) asserts, "[a] person's positionality relates to the extent to which they are privileged, resourceful, powerful, and thus able to navigate and succeed within the dominant social structure" (p. 175). Monroe seemed to understand this point and used his positionality to his advantage.

In the section that follows, a discussion of positional identity is presented. The discussion reveals how three preservice teachers view themselves as teachers and how their positional identity can be leveraged to develop stronger relationships to teaching science and students.

DISCUSSION AND IMPLICATIONS

A Card Sort Activity is developed to frame a discussion of positional identity with three preservice teachers–Junai, Rose, and Monroe. The Card Sort Activity prompts deep discussions around social markers that are most proximal to their identity, i.e., *who they are*. The three cases are windows into understanding positional identity with connections to teaching, science, and students. The individual cases also reveal similar yet different influences of positional identity on views of self and teaching. Other data, such as observations of their teaching, informal conversations, and course assignments, enhance the descriptions from the preservice teachers and provide additional insights in writing their cases and extending the discussion.

The findings show that the three preservice teachers are able to discuss *who they are* in simple and complicated ways. At moments we see strong articulations, hesitations, and sophisticated re-figuring of identity as well as fixed and unchangeable views of identity. However, as noted above, Tetreault (1993) explains positionality as relational positions and not essential qualities of a person's identity. Their conversations of identity and teaching mainly from the Card Sort activity provide some basis for further discussions on positionality, teaching, and students.

First, as I have written previously (Moore, 2008a), "our personal experiences, our identities, thus our positionality, influence what we teach, how we teach, and how we continue to prepare ourselves as teachers and educators" (p. 686). The individual cases reveal the diverse life experiences that Junai, Rose, and Monroe have prior to entering the science methods course. For example, being an Asian American immigrant (Junai), a young White female (Rose), and an Asian American male (Monroe), their conversations on identity emerge from comfortable and contradictory places, relative to their positioning in society. At one level, the preservice teachers discuss seemingly fixed notions of identity, such as gender, race, and ethnicity, and feel a sense of purpose in teaching from these fixed, unchanging positions. This connects to their purpose for entering teaching as a career, their desire to work with specific groups of students, or their preference to teach in particular school contexts. On another level, their positional identities are wonderful examples where stronger connections to science and students can be made; for example, explaining why it is important to have an Asian American female immigrant teacher, with a strong religious background, teaching science in a large urban city, or a young White female teacher who has an awareness to gender issues in an urban science classroom, or an Asian American male teacher in an urban elementary school setting as a role model for students. These kinds of connections have wide-reaching implications to promote equity and diversity in urban schools.

In previous research, I have suggested that understanding the positionality of the teacher is important to classroom teaching and student interactions (Moore, 2008a). In that study, I argue that, "individuals are not the construction of just gender, or just race, but have multiple positions that intersect and create for them their perception of the world" (p. 699). This current study of preservice teachers'

identity expands this notion and reveals the contradictory and powerful positions that the preservice teachers may leverage in order to build strong connections to students, science, and teaching. Furthermore, these examples make known how positional identity can foster critique of teachers' role and purpose for teaching, just as Monroe provides a counter-narrative (Solórzano & Yosso, 2002) to the "smart Asian American stereotype" and what this stereotype means for his choice of career and his placement in urban schools. Consequently, positionality influences how we view self as the teacher, how we interact with students in the classroom, and what we decide to do with our lives.

Second, a focus on positional identity in teacher education can foster the development of relationships with science and students by helping preservice teachers to critique their positioning, whether from positions of advantage or disadvantage, to influence teaching. In other words, "positional factors reflect relationships of power" (Maher & Tetreault, 1994, p. 22) that preservice teachers are unaware of positional identity and its influence on teaching (Martin & Van Guten, 2002). The development of methods, such as the Card Sort Activity to elicit the views of teachers about positional identity and teaching are recommended. For example, "to be Asian, African American, Hispanic, Native American, or White in the [science classroom or in an]…education classroom carries a different meaning with each classification. Yet…we frequently ignore these arbitrary distinctions by proceeding with generic praxis, literature, and discourses" (Johnson-Bailey, 2002, p. 40). Positional identity can assist preservice teachers in defining a purpose for their practice of science teaching while also being critical of how their relative positioning offers both advantages and disadvantages within different contexts– even in teaching subject-matter and students. Preservice teachers may not see these connections as salient; thus, it becomes important that science educators make relevant connections to the histories, experiences, and identities of teachers, as we also come to a greater understanding of our relative positioning as educators (Parsons & Mensah, 2010). More opportunities for preservice teachers to delve deeper into understanding their positional identity in the context of teaching science and teaching students are also recommended.

CONCLUSION

The research on teacher identity does not consider an analysis of positionality and its influence on teaching, learning, and students. Considering the complicated yet rich understandings that come from using an analysis of positional identity, this study pushes educational researchers to consider positionality as fundamental to understanding teaching and identity. From the three cases, further research into the use of positional identity within teacher education is suggested. Exploration of positional identity from re-telling unique personal histories can inform teachers about some underlying reasons for entering teaching that can be used to construct stronger teacher and subject-matter identities and connections to students. If used with preservice teachers at the start of their teaching careers, positionality may be helpful in connecting personal history to purpose of teaching, their role in teaching

subject-matter, and students by leveraging these histories and teachers' positionality in critical ways. Preservice teachers may not see connections between their positional identity and teaching, or subject matter and students; thus, it becomes important that educators make these connections, both the advantages and disadvantages, possible and explicit.

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9. EXPLORING LINKAGES BETWEEN IDENTITY AND EMOTIONS IN TEACHING FOR SOCIAL JUSTICE IN SCIENCE TEACHER EDUCATION

INTRODUCTION

In this study, I develop a cross-case analysis of one inservice and two preservice teachers to explore linkages between identity and emotions as the teachers seek to enact social justice pedagogies. Although clear linkages have been drawn between teacher identity and emotions through work by Zembylas and others (i.e., Zembylas, 2002; 2003; 2004; 2005; Chubbuck & Zembylas, 2008), further research is needed to more fully understand the patterns and processes by which teacher identities and emotions are dialectically related. Individual case-studies revealed that emotions may show teachers' core identities, or transsituational feelings about the self (Rivera Maulucci, 2008), aesthetic and authentic caring role forces that a beginning teacher navigates (Rivera Maulucci, 2010a), and social justice issues a preservice teacher identifies, reflects upon, and responds to, in the process of becoming a teacher (Rivera Maulucci, 2011a). In the following section, I bring together aspects developed in each of these studies to propose an ecological perspective of emotions and identity.

Understanding Emotions

I ascribe to a view of emotions as ongoing commentaries on enduring concerns related to at least three levels of existence: natural (our physical well-being), performative (our practice), and discursive (our relationships and interactions with others) (Archer, 2004). Emotions provide valenced information regarding the strength or intensity of our feelings, as well as whether they are relatively positive or negative. This is not to say that an emotion, such as joy, is inherently positive, or that anger is inherently negative. Rather, our positioning and the social context of our emotions frame whether they may be considered positive or negative. Some scholars make a distinction between emotions and feelings, wherein emotions are connected to judgments about the world, and feelings consist of bodily responses such as heightened blood pressure. However, I take a more expansive view that does not separate feelings from the cognitions, thoughts, or beliefs that frame them (Pugmire, 1998). For example, Pugmire suggests that resentment rests upon at least four cognitions: whom I resent, what I resent, why I

M. Varelas (Ed.), Identity Construction and Science Education Research: Learning, Teaching, and Being in Multiple Contexts, 123–139.

am resentful, and that I am resentful. Such cognitions are preceded by a stimulus (what exists or happens in our environment that causes us to feel resentful) and our bodily response (flushed skin, increased heart rate, etc.) (Milton, 2007). Furthermore, perception of our emotions is typically followed by action (Milton, 2007), whether those actions include verbal actions (what we say) or physical actions (what we do) (Berman, 2007). Whereas the bodily response might wane, cognitions such as that I resent, what I resent, etc., may remain over a long period of time (Pugmire, 1998). Thus, emotions are experienced over time and include cognitions, bodily responses, and actions.

An Ecological Perspective of Emotions and Identity

An ecological perspective of emotions considers the entire emotional cycle (stimulus, bodily response, perception of emotion, action), its connectedness to the physical and social environment, and its evolutionary importance for learning and rational decision-making. With respect to learning, "the mode of an individual human being's engagement with their surroundings is essentially emotional…emotions connect us with our surroundings, enabling us to learn from them, defining the quality of that engagement, shaping our memories and therefore our knowledge (Milton, 2007, p. 71). Milton explains that opportunities for learning exist at each point in the cycle. We can learn new bodily responses to stimuli, we can learn new perceptions of emotions, and we can learn new response actions. Such a view of emotions and learning makes it clear that "we learn with our bodies as well as our minds" (p. 72). At the same time, emotions have been implicated as essential to rational decision-making since they arise "when an individual is neurologically capable of making a connection between *past experience* and *immediate experience* [original emphasis] (Beeman, 2007, p. 282). As we encounter new experiences, we make decisions based on our emotional or "gut" reactions. Without emotions, we would be unable to make rational decisions.

The relationship between identity and emotions is complex. On the one hand, emotions provide information about our concerns and, thus, provide a lens into which concerns are most salient to us and in which contexts. For example, Turner (2002) argues that when a role identity, in this case, teacher, is important to an individual, verification that one is successfully taking on the role is high stakes. Lack of verification could be experienced as a threat to one's identity and strong negative emotions of anger, resentment, fear, or sadness may result. In a similar way, studies have documented the ways in which social identities may also pose threats. Individuals may experience stereotype threats when social cues, such as the number of Latino/a scholars at a conference, heighten one's awareness of that social identity and associated stereotypes (Steele, 2010), such as "Latino/a scholars are not qualified". Stereotype threat includes a bodily response, as individuals may experience increased blood pressure and also fosters emotional perceptions, such as a sense of not belonging. Furthermore, stereotype threat has been shown to cause significant underperformance in members of stereotyped groups, which "is caused directly by its effect of increasing heart rate, blood pressure, and related

physiological signs of anxiety to the point that these reactions interfere with performance" (p. 121). Although individuals might be aware that others have not verified a highly salient role, and will be conscious of their intense anger, fear, or sadness; with stereotype threat, individuals are, for the most part, unaware of their anxiety. In addition, stereotype threat "impairs performance and other actions by interfering with our thinking" (p. 121). In essence, our minds are occupied with coping with the stereotype threat in such a way that working memory is significantly impaired. Our working memory helps us recall and manipulate details and mediates learning, or the transfer of memories between the short-term, episodic memory system, and the long-term self (Conway, 2005).

Drawing on the above ideas about emotions, I envision identity as relational to our unique personal and cultural histories; our goals, interests, desires and physiological states; our roles; and the social context. In addition, our emotions may be seen as one of the central mediators of our identities, or ways of being in the world. An ecological perspective of emotions and identity situates becoming a teacher as identity work fraught with emotions stemming from multiple planes of existence that must be managed. The planes include physical wellbeing (e.g., as how much rest we had the night before), performative (e.g., how well we are implementing planned lessons) and discursive (how well we are relating to students as evidenced by their engagement). At the same time an ecological perspective of emotions and identity expands the discursive dimension to include an array of elements, namely people, ideas, institutions, and places, to which one relates. For science teachers, the discursive dimension may include the tools of science, beliefs about the nature of science and scientific inquiry, understandings of the role of science in society, informal science institutions, and the physical environment of the school. Since we reveal ourselves to others and to ourselves through our performances (Beeman, 2007), the role of teacher, which is reliant upon an audience that may or may not participate appropriately, also renders teachers vulnerable to multiple identity threats. The threats may be associated with role verification or with stereotype threats, such as those experienced by White teachers in predominantly Black and Hispanic schools. To cope with identity threats, teachers must actively navigate their emotions. Emotional navigation refers to the ways in which individuals actively manage their experience and expression of emotions and work to maintain or change a given course of action (Chubbuck & Zembylas, 2008). An ecological perspective of emotions and identity is particularly suited for exploring issues of social justice in science education because it captures the ways in which our beliefs about how the world, our school, our classroom, and science ought to be may conflict with how they are. Given a social justice and ecological perspective of emotions and identity, we can ask the following research questions:

1. How do teachers' emotions frame their enduring concerns and beliefs about science and social justice?
2. In what ways do teachers' emotions mediate their science teacher identities, and vice versa?

GATHERING AND ANALYSING THE TEACHERS' STORIES

Data were collected via critical narrative inquiry, a methodology that employs an explicit social justice framework such that the research serves to foster and document the process of addressing equity issues in science education (Rivera Maulucci, 2010b). Data for this study are drawn from three lines of research with inservice and preservice science teachers. As a district staff developer, I explored three fifth grade teachers' efforts enhance students' opportunity to learn science in a high poverty school. As a teacher educator in a social justice undergraduate education program, I work with secondary preservice teachers and seek to document their process of becoming social justice educators. I also teach a science methods seminar that enrolls inservice and preservice teachers who are learning to teach science in more culturally responsive ways. Data include classroom observations, semi-structured life history and phenomenological interviews, lesson plans, seminar coursework, as well as audio and video data from college and K-12 classroom settings. Data analysis involved open-coding, identifying recurring themes, reviewing pertinent literature, and refining codes; such that both emergent and derivative themes related to emotions and identity were developed (Strauss & Corbin, 1998). Table 1 provides descriptions and examples of codes. In the cross case analysis, I focus on two overarching themes. The first is how emotions serve as indicators of teachers' enduring concerns. The second is how aesthetic and authentic caring role forces shape how teachers individually and collectively construct the "role" of teacher and the emotions they must manage as they navigate contradictions generated by competing role forces. I draw on these two themes to posit a dialectical relationship between emotions and identity.

The Teachers

Elena, a first-generation immigrant from the Dominican Republic was a Neuroscience major in her second semester of a pre-service teacher education program. She enrolled in the science methods seminar during the Fall 2006 semester. The seminar enrolls both in-service and pre-service teachers. In the seminar that I taught, Elena partnered with two dual language teachers from a local, public, elementary school, Ms. Aron, a second grade teacher, and Mrs. Hernandez, a fifth-grade teacher. She spent one period a week over ten weeks observing and teaching in each classroom, and one period a week planning with her partner teachers, for a total of 30 hours of fieldwork. The dual language model in the school called for all science instruction to be conducted in Spanish. Nicole, who self-identifies as Caribbean African-American, was a Chemistry major in her first semester of a pre-service teacher education program. She enrolled in the secondary methods seminar during the Fall 2007 semester. The seminar enrolls students preparing for certification to teach high school English, Social Studies, Mathematics, Science, and Foreign and Classical Languages. As part of the seminar that I taught, Nicole completed 60 hours of fieldwork in a local, public, middle school. The school was situated in a high-poverty community and served predominantly Latino/a and Black students. Tina, a White female of Irish and Italian

descent was the first-year teacher who entered teaching through the New York City Teaching Fellows Program in 2002. At the time, I served as a district science staff developer and director of the science professional development lab housed in the school. Tina was one of three fifth grade teachers in the school who participated in a study of teaching of science for social justice.

Table 1. Sample coding

Teacher	*Vignette- Vignette in which emotions were clearly expressed*	*Emotion- Type of emotion expressed*	*Valence- Degree to which emotions are positive (1) or negative (4)*	*Concern- Concern which arouses or is implicated by the emotions*
Elena	…I was afraid one of the students would correct me, and that's not the first impression I would want to make, the teacher that can't speak Spanish…	Fear	4	Fluency in Spanish
Nicole	… But when I got to [college], I was just really shocked. Like, my eyes were opened at just the educational disparities that exist…	Shock	4	Educational disparity
Tina	… I would cry every day and my husband would be like, "I don't understand." And I was like, "I just don't know how to do it right and no one will tell me."…	Sadness	4	Teaching performance

EMOTIONS AS INDICATORS OF ENDURING CONCERNS

As stated earlier, there is some disagreement across the many fields that consider identity as to whether or not there are stable, or core aspects of identity. Yet, across each of the case studies, I have found stable threads of concern that span the teachers' experiences over time. In other words, what teachers get emotional about tends to be consistent in the context of both their lived experiences and across the time of the studies. In the case of the preservice teachers, Elena and Nicole, their concerns span several semesters in their teacher education program, and in the case of the inservice teacher, Tina, her concerns span two years of the study. Due to space considerations, I provide one or two examples for each teacher; however, other studies reported elsewhere provide additional context and details for these claims (Rivera Maulucci, 2008; 2010a; 2010b; 2010c; 2011b; 2011b).

Elena: Navigating Fluency and Authority

One enduring concern for Elena related to issues of language and fluency. As an immigrant from the Dominican Republic at the age of five, Elena knew what was like to enter school speaking and understanding very little English. She was enrolled in a bilingual education program at a local public school and the fact that the best students were more fluent in English and could read, made her lack of fluency and inability to read in the early grades a source of deep negative emotions about herself. Her story is essentially one of assimilation. In order to succeed, she had to become fluent in English. Fast forward 15 years and she is now in a science teacher education program and on the verge of participating in her first field experiences in a dual language classroom. Yet now, she had to confront fears of being less than fluent in Spanish. She wrote the following in her practicum journal:

> I spend the night before my visit telling my mother how nervous I was to speak in Spanish for an entire class period. Although I am fluent, I do not practice enough to feel completely comfortable giving a lesson in Spanish. I was afraid one of the students would correct me, and that's not the first impression I would want to make, the teacher that can't speak Spanish. However, Ms. Aron's class was not a bilingual class, but a dual language class. She had students that were native Spanish speakers and some that were English speakers learning Spanish. As a dual language class, Ms. Aron gives instructions in English one day and in Spanish the following day. I was a bit relieved.

Elena was concerned about fluency because of the ways in which her lived experiences connected fluency with being a good student. In order for Elena to become a good student, good enough to eventually attend an Ivy League college, she had to become fluent in English. Now, she connects fluency with being a good teacher. She worries that if students have to correct her Spanish, she will lose authority, and students will not respect her. Thus, her fears about fluency connect to another immediate concern of Elena's, her ability to enact authority as a teacher. For example, during the science methods seminar Elena reflected on the management skills of her two cooperating teachers.

> I am always impressed by the control Ms. Aron has over her students. When she is giving instructions, she has a very low and evenly-paced style of speaking. While she was explaining the game, there were two students speaking and she called them to stop. However, she did not have to say the word "stop" in order for the students to stop speaking. She simply said their names and the students immediately stopped and turned to look at her. Ms. Aron told the two students to place a red stick in their name pouches. On the wall next to the door, the students have pouches made of construction paper with their names on the front. The students did not protest and placed the red sticks in their pouches. Ms. Hernandez uses the same disciplinary tactic in her classroom and her students always place red sticks in their pouches when she informs them of their misconduct. I am impressed by the

> lack of resistance from both the 5th and the 2nd graders to the system. I wonder if either teacher has encountered a student that refuses to place a red stick in their pouch. I have encountered many students that protest when called on for misbehaving and insist on the unfairness of the teacher's claim. Acquiring proper classroom management is key to any successful learning environment. Ms. Aron and Ms. Hernandez have acquired this essential skill. I feel classroom management will be one of the most difficult skills for me to master. I try to convince myself that I will be a firm instructor that can take on the authoritative role, but I often feel I will fall to pieces.

On the one hand, Elena is impressed at how the teachers seem to have complete compliance from the students. Students never seem to challenge their teachers' authority. On the other hand, Elena anticipates having difficulties enacting an authoritative role. The following quote expands on her fears.

> I've discussed this issue with other student teachers and I know I am not alone in my fear. I look at Ms. Aron and Ms. Hernandez for tips on how to manage a classroom and I've realized that one of their similarities is their ability to call on students, but not give details of what they are doing wrong. I've always known that when it comes to behaviour, students know what they should and should not do. Teachers do not have to go at length about what students are doing incorrectly. I also noticed that Ms. Aron and Ms. Hernandez never yell or raise their voice. I suppose the key is to remain calm and never lose your composure. Students are able to tell when teachers are comfortable and confident in their abilities. Hopefully after my student teaching, I will have the same confidence and firmness Ms. Aron and Ms. Hernandez possess.

The level of detail Elena notices about the teachers' practices in these vignettes indicates that she consciously attended to them during her observations. She also clearly describes her uncertainty. For example, the statement, "I suppose the key is to remain calm and never lose your composure," indicates either that she is unsure that she will succeed in remaining calm and never losing her composure or that, even if she succeeds in this, she will struggle with conveying confidence and enacting authority in the classroom. Her lack of confidence and firmness is also indicated in her hope to gain confidence and skills during student teaching. Later in the week, Elena planned and taught her own lesson to the second grade class. In her reflection, she evaluated her ability to enact authority.

> Overall, the lesson was a success and the students seemed to grasp the multiple uses of rocks. I met my goal and the essential question I wanted students to be able to answer. However, I realized that I need to work on my presence in a classroom and giving more clear instructions about how I want students to interact during an activity. Instead of having students shout out the answers, I should have told them to raise their hand if they knew whether the item in the picture was made from rocks. I also realized that I need to practice my instructions in Spanish. I often spoke a bit quickly or stuttered

> with certain words. My difficulty with the language may have contributed to students' talking during my lesson.

On the one hand, she notes that students seemed to meet the learning goals of the lesson. On the other hand, she wants to work on her "presence" in the classroom in terms of the instructions she gives and how she structures their participation. In addition, she links her struggles with clarity to her lack of fluency in Spanish and notes, "My difficulty with the language may have contributed to students' talking during my lesson." For Elena, fluency leads to authority, including positional authority (in her role as teacher), epistemic authority (being seen as one who knows), and narrative authority (gained through experience) (Munby & Russell, 1994). As we will see later, being seen as "one who knows" becomes an important aspect of Elena beginning to reformulate her views of scientists and her view of herself as a scientist.

Nicole: From the Pain of Educational Disparity to Radical Hope

An enduring concern for Nicole relates to educational inequity. Nicole grew up in Detroit, became the valedictorian of her high school graduating class, then attended an Ivy League college only to find herself woefully underprepared to engage academically in what the institution had to offer. This experience instilled a deep awareness of educational inequity. For example, in an interview, she said,

> But when I got to [college], I was just really shocked. Like, my eyes were opened at just the educational disparities that exist…It was like ignorance is bliss too, to a certain extent. Because in Detroit, I knew that things weren't right and that other people had more opportunities. But until I got to [college] and really saw, and really had to struggle that first semester with just feeling like I could be intellectually invested, or a part of what was going on academically in the institution…I said, "There's something really wrong here."

This vignette conveys strong, negative emotions, including shock, a sense of wrongness, and righteous anger, upon realizing the extent of educational disparity in society. In particular, Nicole believed she lacked crucial cultural capital and gave the example of not being able to understand the basic plot of the Iliad in a course filled with texts that for the most part she had never heard of. Nicole's experiences directly framed her initial attitudes and resistance towards multiculturalism. In a reading response, she wrote,

> I plan to instruct urban students in public schools. I find it difficult to shift the emphasis in the classroom from more Eurocentric ideas to that which is representative of a diverse array of cultures and histories. This is because these ideas transcend primary and secondary educational systems. The ACT and SAT are all culturally biased….Schools like [mine] have the core curriculum and I want my students to have the tools to be successful on these tests and at schools such as [mine]. How do we adequately prepare students

> for higher education while still teaching them information that is not incorporated into many prestigious colleges and universities?

In this vignette, Nicole conveys her struggles with the idea of incorporating a more diverse array of cultures and histories into the curriculum. In her experience, such knowledge is neither tested nor valued in higher education. She questions its value for students and uses her emotions to resist multiculturalism. Yet, by the end of the semester Nicole conveys a sincere hope that both society and the educational system can change. In her final teaching autobiography, she wrote:

> Multicultural education is about reaching the great potentialities of our society. It is about dreaming the "impossible dream" of a completely egalitarian society, while never for a moment believing that this reality is unattainable. The multicultural educator must transcend that of the past and present and push forward into the future, as vast and esoteric as this may seem…Although the multicultural educator incorporates social justice with specific aims into their curriculum, instruction can never be solely dictated by teacher-imposed agendas. This only creates an oppressive community, vastly different from the community of learners that multicultural educators actively endorse. Rather "teaching for change" involves setting in place a diversity framework so that students are learning and feel empowered while doing so.

Nicole's radical hope resides in her belief that "if someone who really understands and who really can feel the pain of the fact that there's just a problem here can't teach or doesn't want to teach, then who is teaching? Or who should teach? Because who knows better than me?" In other words, Nicole grounds her decision to teach in her belief that because she feels the pain of educational injustice she is uniquely situated to teach for social justice.

Tina: From Sinking to Swimming

The struggles of new teachers are well documented in the literature and Tina's story is further complicated by the fact that she entered teaching through an alternative route and had minimal teacher preparation (Rivera Maulucci, 2010). Tina also was one of five new teachers in her grade-level (only one teacher was a returning teacher). This fact exemplifies the issue of teacher turnover in high-poverty schools, and the scope of mentoring and support that a school must provide. Tina had a difficult first year and I often observed her crying. In an interview, she said,

> I needed support. I had no idea what I was doing and they just kind of left me high and dry and then came down on me all the time about everything I was doing wrong and all I wanted somebody to do was tell me how to do this right because I would have done it. I just wanted to know how to do it right. It was like a guessing game and those people who had it figured out, they loved, but wouldn't help the people who couldn't figure it out…And I just

> constantly felt like I was being dumped on and I wasn't doing anything right. And I would go home at the end of every day and was like, "Oh I did 150 more things wrong today than I did yesterday." And that's what I did every day. I would cry every day and my husband would be like, "I don't understand." And I was like, "I just don't know how to do it right and no one will tell me."

This vignette clearly shows the emotions that Tina experienced related to the performative dimension. Day after day, she felt like she did not know what she was doing and that no one would tell her what to do. She frequently came to tears, a bodily response that shows the intensity of her emotions. One of the ways Tina coped with her emotions was to bond with her colleagues who were also "in the same boat." She said,

> You feel like there's nothing else to hold onto so I'll just hold onto the person standing next to me and hope that they know what's going on because you want to be able to depend on your administration and you want to be able to say, "Now what do I do?" But where are they and how do you find them? So you're like, "Did you see [the Assistant Principal] today? I didn't see her today. Can you tell me how to get to the lunchroom?" I think that a lot of it was in the beginning of the year it was like, "What staircase do you take them down? I don't know. Do you know?" And then who would find it out then report it back to everybody. "If you see her, ask her and then tell me." Because definitely when it's so chaotic like that you have no choice but to hang on to each other like that.

One of the ways Tina coped with the intensity of her emotions was to hold on to the person next to her and to try to gain the information she needed from her colleagues. She tells a story about how, on the first day of school none of the teachers knew how to bring the students down to the lunchroom, and so they all poked their heads out the door and started asking each other. She describes the ways in which the teachers were initially forced to communicate with each other, to learn what to do. However, over time what began as a survival mechanism became a dense network and source of collegiality, solidarity, and support.

Summary

Across the three stories, we see how teachers' emotions frame their sense of self, influence their goals for teaching, and characterize their experiences in schools. In addition, all three teachers express concerns with aspects of their performance. Elena is worried about the ways in which a lack of Spanish fluency will impact her ability to convey confidence and firmness, and thus enact positional and epistemic authority. She hopes to gain fluency and authority through practice and experience. Nicole is concerned with her ability to teach for social justice, to enact a vision of multicultural teaching that is consistent with her beliefs about what students need to be successful in higher education. It is important to note that Nicole's vision of multiculturalism incorporates teaching for social justice. Her emotions regarding

educational disparity are implicated in the goal she set to become a teacher who can work to undo some of the societal wrongs she has identified. She uses her righteous anger to resist the notion that societal transformation is not possible. Instead, she articulates hope. Tina is also concerned with her performance and her ability to enact the role of teacher. The intensity of her emotions indicates that this role is highly salient to her identity and most of her resentment and negative emotions are directed towards those whom she believes will not tell her how to teach. In contrast, sharing information became a way to build solidarity among the teachers on her grade level and to cope with her feelings of being left to sink or swim. For each of the teachers, emotions help us understand their enduring relational concerns, including relationships to students, colleagues, administrators, their teaching context, and to the values and ideals that frame their visions and philosophies of teaching. While only brief examples are provided here, the teachers' concerns were expressed in multiple vignettes over time.

EMOTIONS AND SCIENCE TEACHER IDENTITIES

Emotions are also implicated in the ways in which each teacher relates to science and takes on their science teacher identities. In the following section, I provide examples from each teacher that indicate some of the different ways emotions frame science teacher identities.

Elena: Seeing Herself as a Scientist

The following exchange comes from an interview I had with Elena during the semester following her science methods course. She was student teaching at the time.

Maria: Do you see yourself a scientist?

Elena: I guess I do. No, definitely I do. I think for a while, I've been considering myself a scientist. I think working with Alex [her cooperating teacher] has made me see myself more as a scientist…just because we're doing presentations right now of their science projects. We started them today, and whenever the kids sort of stumbled on something they would look to me or him to say, "Am I saying this right?" Also asking them questions so what did you learn? How do you know this? I feel also that I learn a lot from them as well. So I'm starting to see science more as a collaborative thing, and I don't think that I used to see it that way when I was younger.

Maria: Tell me a little bit about why you didn't see yourself as a scientist before.

Elena: I guess for a while, I figured especially for children, being a scientist means you have to know everything and you have to know certain facts, and I'm starting to get more comfortable about not knowing certain things; and also allowing myself to learn from other people, from children.

In this vignette, we see how Elena's emotions are implicated in her view of herself as a scientist. At first, she is somewhat reluctant to position herself as a scientist, responding, "I guess I do," to my question, "Do you see yourself as a scientist?" Then, she affirms her belief that she is a scientist and relates why. In the vignettes discussed earlier, Elena was concerned about fluency and the impact of fluency on her authority as a teacher. In this vignette, we see how her epistemic authority, being seen as one who knows, supports her positioning as a scientist in the classroom and helps to verify her role as a science teacher. At the same time, she conveys a sense of comfort in not knowing the answers to everything. She shifts from a fear of losing authority to a confidence in gaining authority through her knowledge of science, as well as her ability to admit what she does not know. Her new views of science, as a more collaborative endeavour, one in which she can even learn from children, are associated with her own more positive affiliation with science.

Nicole: Loving and Teaching Science with Passion

Nicole articulates a clear love for science and in the following vignettes; we see how that love translates into her approach to teaching Chemistry. She wrote the following in her science teaching autobiography:

> My love for Chemistry is not just about the science of it all. I am not in love with the idea of atoms or the vastness of Avogadro's number. Simply put, science impresses me; it even stumps me from time to time. What's more, Chemistry supports me in my quest to liberate myself through knowledge and understanding of the world and all its parts. I can live science. I don't have to trust what's in textbooks. I have the power to make discoveries myself, thus feeling as connected to Boyle's Law as Boyle himself.

Nicole sees Chemistry as a subject matter that supports her in her quest for liberation. As a Black woman, she is subject to a double stereotype threat related to the number of women and Blacks who succeed in Chemistry. To overcome or resist the threat, she repositions the purposes for learning Chemistry. Gone are notions of advancement and in its place is an articulation of the ways Chemistry empowers her to understand her world. At the same time, she knows that many students do not have a love for Chemistry. How can she construct a way of teaching that brings her passion and her students' passion into learning? Nicole proceeds thoughtfully and carefully. The following vignette comes from a reflection on her microteaching lesson, a lesson she taught to her peers in the methods course, most of whom were English or History majors. Importantly, her peers were engaged, laughing, and learning during the lesson on radioactive decay.

> The science classroom cannot be boring. I believe that I can express myself just as much as a science educator as in any other discipline. Self-expression is important to me in the classroom. I am a visual learner. I need to see colours and shapes in order to understand. This is what keeps me engaged. I try to keep this in mind when structuring lessons. When a person is fully

> engaged, they learn by default. One of my strengths with this lesson was my overall creativity. I really think long and hard about the most interesting way to present new information. I never assume that I can simply lecture about a topic. As a future science teacher, I think that this mentality will benefit my students. In the future, I believe that I can create an ideal science classroom setting. I did think my lesson was creative, but I also felt that it was a little unorganized at times. My goal is to find that divine balance between fun/organic and structured/effective so that activities run more seamlessly.

Nicole makes it clear that she sees her teaching as an expression of her identity. Her affinity for creativity, colours, and drama must be a part of how she teaches. Although she draws on what helps her to learn Chemistry, that she needs "to see shapes and colours in order to understand," as she formulates her approach to teaching; she also articulates the ways in which this is a work in progress as she strives to find a balance between "fun/organic and structured/effective" activities. Nicole's emotions in teaching become resources that her students can draw upon to connect to Chemistry, and her student's engagement and enthusiasm become resources she can draw upon to affirm her teaching identity.

Tina: Letting Go and Letting Students Learn

As stated earlier, the role of teacher was highly important to Tina, and thus, for her, role verification was high-stakes. Across the two years of the study, Tina particularly struggled with issues of control and her need for affirmation of her teaching role. On the one hand, she wanted her students to experience a more investigative approach to learning science, but on the other hand she was afraid to let go of the learning process. She explained,

> It's the control thing. I don't want to give it up because I'm afraid of what's going to happen. I've gotten better at it, but it's still, I always feel like I'm on a schedule and if I don't move them along, and if I don't push them further they're going to be behind. I always feel like I'd like to give them more time to explore things, but I feel like I have to stick to this schedule. So sometimes I'm like, that's it. We have to move on.

Tina and her colleagues co-planned their science lessons and Tina felt that she had to stick to their plan. She avoided deviating from the plan, or being spontaneous and responding to students' interests, out of fear of what would happen. The following vignette expands on her concerns with control:

> I wish that I could differentiate my instruction. I feel like I still have a really hard time with, "And this group will do this project, and this group will do this project…" I want everybody to do the same project because I feel like I need to be in control of it. And I wish that I could let that go…I wish that I could have more than one thing going on in the classroom at once, and I don't feel I can give up my control yet, because I don't think my management is as good as it needs to be yet.

Tina was afraid of what might happen if she let go of her control. In order to establish effective classroom management, Tina believed that she had to stick to the plan and have all her students doing the same activities. The following vignette comes from an interview during her second year of teaching. Unlike the first year, Tina was much more successful and confident as a second-year teacher and she began to be more flexible. For example, she extended an owl pellet unit when she saw that students were engaged with the topic and the owl pellet dissection. In articulating the meaning of science for her students, she also recognizes the meaning of their learning for her sense of efficacy. She said,

Tina: Yeah, definitely, they love science because it's hands-on. So it's important to them, just in the aspect of it being not literacy or math. Coming down here makes them feel very important and writing up lab reports as 5th graders; that's a big deal for them. And the vocabulary that they use is…so much more advanced in science and math, also because it's like a whole other language. So, you'll hear them using quite big words in science or math…One of the kids today was reading a question, "What is an ecosystem? An ecosystem is…"

Maria: There's also self-esteem involved in there because they grasp this vocabulary and they're able to use it in the right way.

Tina: Yeah, for them and for me. It makes me feel good too. (Laughing) "Ah! They got it!"

The vignette conveys her belief that students love science because it is hands-on. In a school that prioritized literacy and mathematics, science was something different and new. She also believed that students felt good about themselves when they learned science because of the technical vocabulary involved. When I linked students' knowledge of vocabulary to self-esteem, Tina not only agreed, but she stated that she too felt good, because "They got it!" For Tina, affirmation of her science teacher identity, and her sense of efficacy came from students' engagement in, and mastery of science.

Summary

Across the three examples, we see how teachers' emotions related to their beliefs about science or their sense of efficacy in science or science teaching, contribute to their science teacher identities, and the ways in which their science teacher identities influence their emotions and their beliefs. In the context of her student teaching placement, Elena begins to reframe her beliefs about science and scientists. Whereas before she thought scientists needed to know everything, now she is more comfortable not knowing everything and learning from her students. At the same time that students begin to affirm her epistemic authority, or her knowledge of science, she begins to see that she does not need complete epistemic authority. She conveys a sense of comfort with not knowing

everything and a sense of enjoyment of science as a more collaborative endeavour. Nicole's strong emotional connection to science frames her beliefs about how it should be taught. In order for students to connect to learning science with the same passion that she does, she believes that her teaching needs to be creative and liberatory. Tina's fears about loss of control constrained her teaching. However, affirmation for her science teacher role, from the students and her colleagues enhanced her confidence and self-efficacy as a science teacher.

CONCLUSION

An ecological perspective on emotions draws attention to the ways in which a dialectical relationship between teachers' identities and emotions mediates the relationship between their beliefs about science and their science teaching practices. Some concerns, and the emotions they engender, endure over time, which shows how some aspects of identity may be more salient to science teacher identities. Teachers' emotions also show when they feel that roles important to their identities, such as teacher or multicultural educator, are affirmed, or not. Emotions influence the goals teachers set and indicate the intensity of their relationships to ideas, to their beliefs about science, to others, and to science teaching. Both time and context are dimensions that cannot be separated from analysis of identity and emotions. Emotions and identity have historical, remembered, aspects that influence the present. Over time, emotions shape teachers' identities and teachers' identities shape their emotions and their science teaching practices. Thus, emotions and identity dialectically construct and reconstruct each other in the ongoing streams of social life.

Figure 1 depicts some of the ways in which teachers' identities and emotions mediate their beliefs about science and science teaching. If we consider a teacher's personal-cultural history and beliefs as internal, and the environmental-social context and practices of science teaching as external, then teachers' emotions and identities become the interface between the internal and the external. While the figure shows emotions as separate from identity, this is only to convey some of the pathways by which teachers' beliefs about science teaching and their science teaching practices influence their identities and emotions. This model foregrounds the science teacher identity, but recognizes the ways in which other identities less salient to science teaching may also mediate science teachers' identities and emotions. The model also shows how one's science teacher identity is dialectically constituted by beliefs about science and science teaching practices, both of which are mediated by one's identities and emotions. Furthermore, one's identities and emotions are dialectically constituted by one's personal-cultural history and the environmental-social context.

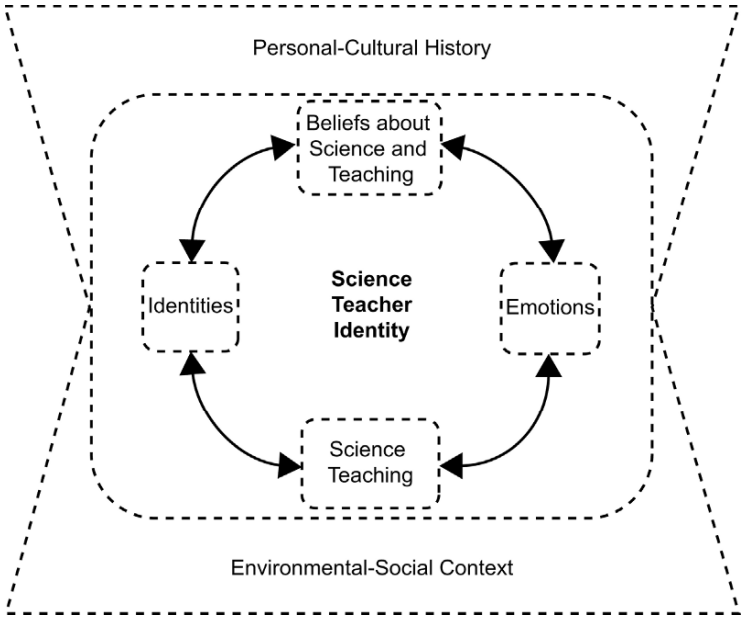

Figure 1. Identities, emotions, and science teachers' beliefs and practices.

The ecological context affords or constrains certain emotions or the performance of certain identities. For example, teachers may be able to exert agency, and use their emotions to resist injustice, negative affirmations, threats to their identities, or fears of failure. Such emotional resistance and the concomitant identity constructions are central to enacting social justice pedagogies (Chubbuck & Zembylas, 2008). Passivity may also play a role in that teachers' enactment of science teaching may be constrained or enhanced by the social context of their relationships with students, colleagues, and administrators, their relationship to science, their positionality on a developmental trajectory as teachers, and the sociocultural context of their school, including historical and current demographics, resources, and policy environment. Ultimately, emotions, both positive and negative, provide the potential for individual (and collective) transformation. Emotions and their implications for teachers' identities or the potential for identity transformations remain understudied in the field of science education. Attention to the ecology of teachers' emotions, identities, and lives in schools is crucial if we are to begin to realize the goals of social justice in science education.

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10. COLLIDING IDENTITIES, EMOTIONAL ROLLER COASTERS, AND CONTRADICTIONS OF URBAN SCIENCE EDUCATION

There is widespread acceptance in contemporary scholarship that identity is dynamic, constantly changing as individuals enact their lives (Stetsenko, 2008). There are many ways to think about identity theoretically (Roth & Tobin, 2006) and in this chapter we foreground autobiography involving an immigrant teacher who came to the US from the Philippines to pursue a higher degree in environmental chemistry, and subsequently to teach in New York City. Like him, most of his students were immigrants, but mainly dark skinned individuals from the African Diaspora and native speakers of Spanish. This teacher, Reynaldo, is coauthor of this chapter in which we regard cultural enactment of activities as historically constituted, and identity as closely related to lived history. A critical priority in our framework is that the basic unit for analysis is social interaction (Goffman, 1983). When social life is enacted, individuals may think about what they do independently of others or in relation to groups of others. We regard identity as mediated by an individual collective[1] dialectic in ways that are complex. The social connections between individuals and various resources mediate enactment of culture and the extent to which goals and motives are accomplished. It is important that individuals' actions are in synchrony with one another and also orientate over time toward goals and motives. The ways in which individuals connect and network with others (i.e., the direction and strength of social bonds) and with other social artifacts are important structures that afford enactment.

One way to unpack identity initially is to ask the question: how does a person consider him/herself in relation to those with whom she/he interacts? Of course this idea needs to be fleshed out because it is oversimplified. A person's identity is mediated by ascriptions of other individuals and collectives. Not only do we theorize culture as enacted consciously and goal oriented, but also we include how being present in a field with other individuals simultaneously creates culture that is neither goal-oriented nor consciously enacted (Heidegger, 1962). That is, agency and passivity are dialectical components of cultural enactment (Roth, 2007). The ascription metaphor is symbolic in that it places value on such aspects of social life as what is done, how well it is done, and whether it was worth doing. Ascription may reflect a person's experiences of another's practices (he is good) or actions based on prejudice (he is a male), hearsay (this guy is a keeper), and the history of being with this person or others like him (he is always pleasant). Accordingly, the

M. Varelas (Ed.), Identity Construction and Science Education Research: Learning, Teaching, and Being in Multiple Contexts, 141–156.

attributes of an individual as well as his/her enactment and self-constructions of identity constantly structure social life within a field.

Building on the work of scholars such as Wolff-Michael Roth and Yew Jin Lee, our research group began to think of fields in terms of cultural, historical activity theory (Roth & Lee, 2007). That is, a field (Bourdieu & Wacquant, 1992) might be defined in terms of the activities undertaken in it, foregrounding enacted mainstream culture, initially in terms of the goals of individuals and the motives of a collective. Numerous resources structure cultural enactment in a field. Since we theorize fields without boundaries, the culture produced in any field can structure other fields as well (Tobin, 2010). That is, fields are totally miscible. Hence, Reynaldo's lifeworlds, dating from his childhood through to his current life as spouse, parent, science educator, and researcher all contribute to his identity, which is historically constituted and dynamic because the structures of his lifeworld are continuously changing. Structures consist of mental schemas and materials and are resources for cultural enactment, which arises when structures are appropriated through agency and passivity, which are dialectically related (i.e., they co-exist as parts of a whole). Agency is conscious and goal directed–a means for individuals to change their identities by participating in activities in a variety of fields. At the same time cultural enactments inscribe identity changes over which an actor has no control by passively appropriating a structural flux while being in a field with others. From this theoretical perspective, as culture is enacted, identity changes continuously.

GROWING UP

Reynaldo, with six brothers and a sister, grew up on a farm in a rural area of central Philippines. His father was a tenant farmer and his mother a homemaker. The family was poor, earning a low income but managing to survive through subsistence farming.

Once they completed elementary school it was typical for children in the Philippines to leave school and start work. However, Reynaldo was committed to continuing with his education and obtained a scholarship to study at a Catholic high school in a city some distance from his home. He left home to live in a residence at school, and was strongly influenced by Catholic brothers at the school. During his high school years Reynaldo increasingly became an activist against widespread oppression of the working class.

Reynaldo graduated from high school as valedictorian and received a scholarship to attend an American university in the central part of the Philippines. He opted to study chemistry rather than agronomy because he did not want to be associated with more farming, and chemistry was perceived as a difficult subject which few people studied, thereby increasing the chances of finding work after graduation. This decision allowed him to accept a position as a university lecturer, teaching chemistry and doing research on the environmental impact of mines owned by the country's dictator. As a research scientist Reynaldo experienced adverse political effects when the military took action against him and his

colleagues for publishing results that depicted deleterious environmental impacts of mining.

It took courage to speak out when inequities were identified and unfair practices were enacted. In the Philippines the consequences for publishing facts that reflected badly on those with power were extremely grave. As Reynaldo was to learn in New York, when he taught science, school administrators also expected teachers to be compliant and when they were not, there were consequences (albeit not as grave as those he had faced in his native country). Actions often were taken to discourage the faculty concerned from remaining at the school. In Reynaldo's case his actions to stand up for the rights of students, colleagues, and himself led to friction with school administrators in each school in which he was employed.

THE CENTRALITY OF SPIRITUALITY

Spirituality was an important component of Reynaldo's identity as a child and subsequently in his adult life.

> Reynaldo: Growing up in a rural area, I was exposed to folklore, superstition, and faith healing activities of my great grandparents. I drew my strengths from these beliefs, customs and traditions akin to the practices of American Indians in the US and Maori people in New Zealand. At the age of six, my way of crossing-over to the spirit world was already very strong. My memory was photographic, and I used it to excel in academics from elementary to college. The influence of my grandparents was more of an affirmation of my spiritual growth. Of more than 30 grandchildren, our family thought that I was the chosen one to receive the spiritual powers that my folks left when they departed from the physical world. It was part of our customs and traditions to be handed down to the succeeding generation.
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> A year after I completed my bachelor's degree in chemistry, I was diagnosed to have an enlarged heart. I was brought to one of the prominent faith healers in the province who helped me recover and who, in the succeeding seven years, trained me in alternative medicine. He told me that I was born to be a faith healer and would be known throughout the world as one of the best. Becoming a faith healer was an exploration of the unknown and the unseen.
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> I continue to communicate with spirits through dreams, especially in predicting natural calamities, wars, dangers coming, difficult people and places that are unsafe. Also, I communicate with spirits (e.g., the departed souls of friends and relatives), and spirit entities that exist in different dimensions but are in the same physical world. I believe there are other entities that exist but humans are not able to physically see them. Having this connection with the

> spirits, I feel safe and secure. It makes me feel hopeful and optimistic, i.e., there is more beyond our physical world and if only humans can harmonize with the natural powers that are yet to be discovered, our physical existence will be much more meaningful. I consider spirituality to be one of my strengths in confronting adversities and in making informed decisions in this physical world.

Reynaldo's spiritual practices, together with his practices as a scientist and science educator are central to his continuously changing identities. The following questions and answers provide deeper insights into the centrality of spirituality in Reynaldo's identities.

Ken: How did your spiritual beliefs and practices mediate your roles as a science teacher?

Reynaldo: My religious beliefs and practices have provided me with directions to make sure that my students are getting the help they needed to be successful in their own lives. I treated every student in my classroom as my own child–assuming that every one of them can learn and will learn good things from me. I became more understanding and compassionate especially with those underprivileged struggling students. I became sensitive to their issues and problems at school and in their homes. I picked up these issues from their actions in the classroom and from their parents/guardians during parent-teacher conferences.

Ken: How did your religious beliefs and practices mediate the quality of your interactions with students, colleagues, and other stakeholders?

Reynaldo: I became more proactive than reactive to people and situations. It has been my practice before I sleep to ask questions and visualize: What is good tomorrow and what could go wrong? I tend to classify people who I interact with, paying more attention to those who are difficult to deal with. I can sense the negativities of some of the people toward me in the school building ahead of time and this always affects me–making me uncomfortable and agitated. I tried to avoid these people and places. There were times though that I lost my patience and confronted them head on. My religious beliefs and practices have inculcated in my mind that there is always goodness in every person and that it is the evil thoughts that drive individuals to act directly or indirectly to hurt others.

Ken: In what ways was spirituality salient to being a science teacher/science educator?

Reynaldo: I believe that human existence is like a coin: One side is physical while the other is spiritual. To fully exist we need to consider both cognition and emotion of human mind. It is the spiritual side that cultivates our emotional being–and this separates us from all the

rest of living and non-living entities. As a teacher/educator I believe there is more we can offer; more out there aside from understanding our physical world. Humans are more capable of discovering and uncovering what is already in the world. There is so much inside of our human world that we need to examine and mindfulness is one channel we can start with. There is so much power within us but we are busy looking outside. We need to look inside.

Ken: Do you feel contradictions within your identity as a medium and faith healer on the one hand and as a Catholic on the other?

Reynaldo: Yes, I realized a long time ago I have lived my life with many contradictions. My first encounter with a "near death experience" totally changed my religious beliefs and outlook in life. Although the Catholic Church generally condemned faith healing practices during that time, I continued to mediate my healing practices with my Catholic religious beliefs. Those that were cured through my faith healing became regular devotees to Catholic faith. Nowadays, it is commonplace in Catholic churches in the Philippines to have healing ministries.

Ken: The other source for contradictions seems to be between your religious practices and beliefs on the one hand and your practices as a scientist and science educator.

Reynaldo: I remember a comment made by one of my patients in Manila in the 80s: "You are a chemist but why do you believe and communicate with the spirits." It reminded me of how I connect with the spirits. To me, this is the greatest contradiction in my life– between hard science and the unknowns/unseen! I believe that my becoming a chemist has been planned a long time ago despite many economic hardships I went through. As early as seven years old, I was already testing the efficacy of some medicinal plants I collected to cure sick people and animals. My grandfather used herbs in his faith healing practices. This practice became partly connected to my interest in pursuing chemistry instead of agronomy in college. Presently, I use my knowledge of chemistry to continue my interests in aromatherapy and herbal medicine. I have tried to modernize my old faith healing practices!

WORKING AS A SCIENTIST

Reynaldo left his University position in the Philippines to work for a multinational corporation in the area of pollution control. As a chemist he rapidly assumed a leadership role, overseeing more than a hundred professionals involved with environmental management. In this high status position he got to know officials from the World Bank who had funded geothermal projects he was administering. For twelve years Reynaldo assumed leadership positions as a scientist and

administrator with wide-ranging responsibilities. After the 1986 revolution in the Philippines he seized the opportunity to accept financial assistance to come to the US to study for a master's degree in water chemistry. After graduation Reynaldo was involved as a scientist and administrator in a variety of projects in the US and the Philippines and traveled extensively throughout the world. Reynaldo was respected by his peers and employers and because of his competence he was offered positions in the US and received a scholarship for his graduate studies in the US. After his graduation he was employed in the US and the Philippines, being responsible for administration of large budget grants and numerous personnel.

SCIENCE TEACHING IN NEW YORK

Although he was a successful scientist and project manager Reynaldo valued his family relationships and responsibilities to such an extent that he sought a job as a teacher to avoid being away from his family for so long. He lived in New York and obtained certification as a science teacher. During an interview for a job as a science teacher Reynaldo overheard the person who had interviewed him recommending not employing him because he would be unable to manage students. Because of Reynaldo's diminutive size the interviewer felt that he would not be able to effectively control his students. Exercising his agency, Reynaldo spoke with the hiring officer, requesting that she give him a chance to teach. She agreed and he worked in the South Bronx for two years, in a new high school of approximately 200 students. However, Reynaldo's role as union leader in the school led to conflict with the principal and this was a primary reason for him leaving to accept a position as a chemistry teacher at a comprehensive high school in Yonkers, for about 6000 students. Conflict with administrators was to be a recurring theme.

In the large high school Reynaldo focused on providing assistance for at-risk students to successfully meet graduation requirements. After five years at the school he and some colleagues of color were informed they were being reassigned to a middle school because of budget restrictions. Reynaldo felt that racial discrimination was involved and he protested publicly about the reassignment. He was disappointed especially because he had developed a new curriculum that had a laboratory focus and it did not seem fair to be reassigned before he could teach the curriculum he had developed. Nevertheless, he searched for another job and was hired at New York High (NYH), in the Bronx. The collaborative research we undertook as the basis for this chapter is situated in classes taught by Reynaldo at NYH.

COLLABORATING WITH STUDENTS TO PRODUCE SUCCESS

In his first year at NYH Reynaldo was tangentially involved in a study in which cogenerative dialogue (i.e., cogen) was used to improve the science learning of youth at NYH. Christopher Emdin, then a teacher researcher, used cogen when he taught physics to the inaugural freshman students at the school (Emdin, 2010). In

their sophomore year the students took chemistry with Reynaldo and the research continued, but Reynaldo was not a co-researcher. In cogen a teacher and others with a stake in a particular educational field dialogue about their shared experiences with the goals of collaborating to identify ways in which to improve the quality of teaching and learning in the field. Reynaldo perceived cogen to be associated with an array of positive benefits that included increased attendance, less tardiness, higher-quality homework, improved social bonding among students, and the emergence of leadership skills. Accordingly, he decided to study the enactment of cogen in his own classes with the goal of improving learning environments by enhancing the social relationships between he and his students and among students (Tobin & Llena, 2010).

Reynaldo was convinced of the value of cogen and used it routinely with the goal of improving the quality of teaching and learning. Often he focused dialogue on students who were struggling or created problems in the class for one reason or another. For example, in numerous cogen activities participants discussed the specific issue of how to help Carlos, a disruptive student, to succeed. In most cogen activities the dialogue was symmetrical in terms of who spoke and listened, an explicit assumption being that all participants shared power and responsibility to ensure that what had been decided was enacted.

As a teacher at NYH Reynaldo explained that students and others often considered his race to be Chinese because of his physical appearance. For example, one day during a class Carlos, an immigrant from the Dominican Republic, called out to Reynaldo, referring to him pejoratively as Chino. Although Ken was there at the time it was not clear to him whether Carlos was taunting Reynaldo or whether he was insulting him as a way to earn social capital with his peers. Whatever the purpose, the comment was a racial slur that was inappropriate, even in an urban context where racial slurs such as these commonly occur. Reynaldo positioned himself during occasional altercations with students as a tough teacher who was unafraid. In this case, his in the moment response was to ask Carlos: “So you think I am Chino. Look carefully. Do I look Chinese?” Reynaldo pointed out that he was Filipino and that he did not have many of the characteristics of Chinese. During a subsequent cogen, Reynaldo asked Carlos why he referred to him as Chino. Carlos smiled and lowered his voice, almost whispering, “some love. It’s my way. Playing around wit you.” In the moment Carlos was kind and caring in the way he spoke to his teacher, showing him the utmost of respect. Reynaldo accepted Carlos’s explanation and moved the dialogue forward. We provide this example as an illustration that cogen often afforded the resolution of problems that arose in the classroom and at the same time fostered excellent relationships among all participants in cogen (e.g., between the teacher and students).

TEACHING ON AN EMOTIONAL ROLLER COASTER

Often Reynaldo was treated like an object at NYH, a school resource that could be manipulated, without consultation. Even though his students obtained good passing grades on the Regents’ examinations[2] the school leadership rarely acknowledged

his effectiveness and innovations–such as doing research in his own classroom, and using innovative collaborative methods that were also adopted by his colleagues. In his third year at NYH Reynaldo, who was certified to teach chemistry, was assigned to teach Living Environment to "lower track" classes in which regular, low performing students were rostered with special education students. The reassignment occurred without Reynaldo being consulted. Because the percentage of special education students in these classes was as high as 80%, a certified special education specialist should have been assigned to coteach with Reynaldo. Instead, Fereny, a teacher certified for teaching English as a second language (TESOL) was assigned to the classes. There was a lack of alignment between the needs of the class and the services Fereny could provide. Furthermore, she was not popular with the students who preferred Reynaldo to teach them. Accordingly, her primary roles involved routine administrative tasks such as checking and collecting homework.

A continuous source of negative emotions related to disappointment and sadness was the comparative lack of status Reynaldo experienced as a teacher and lack of respect and professionalism displayed by school administrators who often seemed to act in ways that disadvantaged students. On the one hand it was obvious that the school's resources, including personnel, were limited and decisions were made to maximize benefits and minimize harms. More than likely, this was the reason Fereny was assigned to assist students in the Living Environment class even though a special educator should have been assigned. Another example involved Reynaldo being re-assigned to teach a new class without being consulted. Despite Reynaldo's assurances that he would teach his Living Environment class for the two years until they sat for the Regents' examination, at the end of the first semester with them the school administration reassigned Reynaldo to teach a non-Regents' class. To remove Reynaldo midstream from teaching a class to which he was assigned seemed unwarranted and had the appearance of punishment. Even though the decision might have been judged to be in the best interests of students, the decision was enacted without consultation with Reynaldo, who was informed after the decision was made.

The Emotional Flux While Teaching

Identities that mediated teaching were structured by macro, meso, and microstructures associated with, for example, policies and practices originating at national, state, and local levels. The structures created major contradictions for Reynaldo, who suppressed or set aside many of his priorities and values in conforming to others' mandates and expectations. Contradictions arising from differences in what Reynaldo felt he was *required* to do compared to what he *preferred* to do afforded a buildup of negative emotions and actions that often did not cohere. For example, a lesson on units of measurement began with Reynaldo seemingly agitated with the class, raising his voice as he exhorted them to get underway. There was the background buzz of noise and Kelly's voice stood above the rest as she asked: "why you always fighting with me?" Reynaldo was impatient

to get on with the lesson because he had been absent and while he was away the students had done poorly on a test on this very topic that had been taught by Fereny. The students were disappointed they were tested on work that had not been taught clearly and Reynaldo was trying to make up by re-teaching them. Like Reynaldo, Kelly had been absent for a lengthy period of time and had returned just in time for the test. She had been a participant in cogen since the beginning of the semester and was accustomed to speaking openly and honestly with Reynaldo and having him listen respectfully to what she had to say. On this occasion her voice did not appear to count and she seemed agitated and confused that she could no longer give suggestions on how to improve teaching and learning in the class without running up against a power imbalance between Reynaldo and her. Because there are no borders between the fields of cogen and the associated science class, it was automatic for Kelly to make suggestions to Reynaldo with an expectation that he would listen carefully, consider what she had to say, and build on her ideas. On this occasion, however Reynaldo enacted traditional teacher centered practices. He remarked to the class on several occasions, "this is my show. Let me finish." Accordingly, Kelly was ignored, and Reynaldo barked commands at the class, exhorting them to pay attention and work quickly.

Sixteen minutes into the lesson students had settled down and were copying notes from the board. Reynaldo, reflecting the emotional climate of the class, was calm and relaxed. "Hecto or kilo? Which is smaller?" he queried. Then, when he received the right answer he proceeded to discuss migration of birds from Canada to the US, asking whether to express the distance the birds traveled "in centimeters or what?" The students got the idea and for the most part they showed signs of boredom in their faces and body posture and engaged continuously in side conversations as they monitored what Reynaldo was doing on the whiteboard. The students had little focus, drifting in and out of participation, seeming to monitor the lesson while participating in social chitchat. As Reynaldo taught from the front of the class, Fereny moved from group to group checking on student homework, and a new teacher[3] prepared work on the front whiteboard for the moment she would take over the teaching of the class. In a relatively short period of time Reynaldo exhibited a range of emotions, beginning with frustration, which occasionally built up to anger and then enacting positively valenced emotions related to happiness as the students' practices aligned with his goals for the day. When Reynaldo announced that students had two minutes left to copy the material from the board there was a predictable protest from students who had not been copying the notes. At this stage Reynaldo made a joke, mimicking a clock ticking down towards zero. The emotional climate was positive and Reynaldo and others in the room appeared relaxed.

Kelly leant across to speak with a peer from her buddy group about whether she could understand an example that Reynaldo was explaining. Her action was consistent with many conversations about coteaching that had occurred in cogen– that students could engage in peer teaching in quiet and unobtrusive ways. Noticing that Kelly was speaking to a peer Reynaldo requested that she answer a question he had posed to the class. Kelly regarded it as grossly unfair that

Reynaldo had called on her when she was doing what they had agreed to do in cogen. Kelly exploded in protest ("you see twenty other hands up and yet you pick on me") and an angry interaction sequence ensued. Kelly spoke with emotion, synchronizing gestures, head movements, and the cadence of her voice. As the flux of negative emotions increased Reynaldo's utterances explaining how to change units of measurement were interspersed with comments about Kelly's rudeness. The altercation continued as Reynaldo and Kelly both uttered words and phrases that exceeded their average loudness. Kelly's tone was accusing and disrespectful and Reynaldo's words were taunting. The students appeared to laugh at the scenario in which Kelly stood up to an authority figure and used words and prosodic features that would land her in trouble with school administrators. Some students, especially those from her buddy group, seemed to use laughter to goad Kelly into escalating the altercation while others laughed collectively at the risky and unusual circumstances of both actors, whose actions violated the norms for teacher-student interactions.

BE CAREFUL WHAT YOU WISH FOR

Cogen and buddy groups are sites for forging new identities. Each field involves the production of social bonds and networks and has goals associated with autonomy and emancipation. As participants enact new culture they enjoy success in working collectively and building new identities as they suggest and enact new strategies. It is little wonder that students like Kelly become confused when they begin to enact what they agreed to in cogen and find that the teacher is not open to them acting in this way on this occasion. It is understandable that in such circumstances students initially support one another in an endeavor to hold to their commitment to assume collective responsibility for enacting changes that have been agreed upon. It is also understandable that Reynaldo felt the pressure to re-teach the subject matter that Fereny had not taught well. He was committed to "getting it right" and resorted to a tried and tested way of teaching in a situation where the teacher has control over the students. For the moment at least he rejected collective approaches to teaching and learning in favor of the individual "running the show." When the students were compliant, Reynaldo was relaxed and the emotional climate was positive. In contrast, when the students were not participating and engaged in side conversations, Reynaldo became frustrated and angry. He regarded such distractions as forms of resistance and in the moment negative emotions quickly spread among the students. By the end of the lesson the altercation involving Kelly, her buddy group, and Reynaldo had occurred and it was desirable that cogen focused in part on what happened to catalyze the angry clash in the classroom and what could be done to avoid similar occurrences in the future.

What happened in the cogen is a good illustration of fields having no boundaries. Reynaldo was late in arriving and the cogen got underway without him. The participants were a new teacher, Kelly, and her two buddies. Prior to Reynaldo joining the cogen, the dialogue was cordial and included high levels of

compassion among the participants as they discussed Reynaldo's roller coaster emotions and recent problems with his health. The students were concerned that their teacher was not well and they wanted the classroom to support learning and the good health of their teacher. As Reynaldo joined the cogen Kelly commented: "Hello. Why you so cranky? Why you so cranky?" Reynaldo's response was slow paced, measured, and emotional. He remarked, "I'm sick for like since last week and the more the more people aggravate me, I become sick." During his response Cindy made an effort to show empathy when she remarked after the word week, "so that's when you..."

The anger that had characterized the argument in the classroom reemerged in cogen as the participants began to argue and reenact roles that were similar to those enacted earlier in the classroom. Reynaldo used cogen to present the rules for speaking in the classroom. As he had done in the class Reynaldo endeavored to assert his role of being in charge and having control over the students. Although this positioning is consistent with the policies and practices adopted throughout New York City it is inconsistent with the tenets of cogen and the idea that responsibility for teaching and learning is distributed across the individual| collective dialectic. His standpoint was consistent with the idea that there was one official teacher who had the responsibility to control the class and maintain a "one speaker at a time" learning environment. The three students wanted to discuss specifics, some of which arose earlier in cogen when Reynaldo was not present – that is, inconsistency and favoritism. Also, when Reynaldo invoked Kelly's name and referred to the dispute that arose during the lesson, Kelly began to defend her actions, speaking for approximately 30s. She argued that Reynaldo's actions were not just and noted she was picked on because she asked her nearest neighbor whether she understood how to do the conversion of units.

In this cogen Reynaldo pursued the goal of establishing rules related to the teacher *having authority and control over students* and ensuring the group accepted them. Conversely, students pointed out Reynaldo's inconsistencies in enforcing existing rules and appearing to have favorites. As the cogen progressed student utterances seemed to change in purpose from showing empathy to producing solidarity and then to contesting the reasonableness of Reynaldo's actions earlier in the day. The dialogue that initially characterized this cogen dissipated as an argument emerged, characterized by points and counter points. As had happened in the science lesson, Reynaldo appeared to taunt Kelly when she made a claim about not feeling well.

What happened in the classroom was reproduced in cogen. The identities enacted by teacher and students, here represented by Reynaldo and Kelly, were not unlike those often reported as characteristic of the dysfunction of urban schooling (Tobin, Seiler, & Walls, 1999). Yet they are a striking contrast to what typically happens in Reynaldo's classes and in cogen. In the anomalous activities described here it was as if a master switch were thrown to afford enactment of traditional fare–forms of practice grounded in power struggles, resistance, and suppression of learning opportunities. Cast aside, for at least the moment, were rosy prospects of

increased learning in environments characterized by collaboration, empathetic dialogue and listening, and positive emotions.

TEACHING MAKES ME SICK

Reynaldo encountered discrimination, organizational frameworks in which his autonomy was truncated, and limited support for his efforts to cater to the needs of students. The power structures were such that he was told what to do and how to do it and if he pushed back to any extent he was penalized in terms of advancement. Becoming and being a science teacher were socially violent to Reynaldo and he was perplexed that structures were in place to prevent him from contributing as much as he could have to the education of the youth who so desperately needed high-quality learning environments in which to learn and transform their lifeworlds. As is evident in the following question and answer, Reynaldo experienced considerable stress as a teacher and his health was impacted negatively.

Ken: At times you seemed to be on an emotional roller coaster.

Reynaldo: I was always driven to be more creative and proactive in redesigning the curriculum to address their needs–forgetting my own self, which subsequently resulted in my deteriorating health. I experienced so much stress realizing that the job was too much for me when I was not getting any help from the school administration. I embrace Hillary Clinton's mantra, "it takes a whole village to educate one child. "I think the emotional displays (e.g., anger and sadness) I had at NYH were the result of me becoming impatient and frustrated with how the system operates. These were on top of physical weakness and muscular pains I encountered due to diabetes. I just felt so much helplessness in that school. I had this recurring feeling of not being able to fully help my students–that the impact of my presence there would be reduced to a minimum. This was why I shifted to teaching new teachers at the graduate school with the hope that each teacher I taught could reach out and help more students.

To an increasing extent the stress associated with continually resisting what he regarded as poor decisions of administrators began to mount. Evidence of stress often was apparent in the way Reynaldo interacted with students, school administrators, and colleagues. He found that he got upset frequently and when he did so he felt tired and unable to work with the high energy he preferred to bring to his job. He began to experience dizziness and lack of energy, but he ignored these signs of failing health. Reynaldo noted that he lacked patience with students who acted up or were not listening and he was frustrated when his efforts to be kind were regarded by them as being soft. At home he found he could not sleep easily and when he slept he had difficulty waking up. Eventually the high incidence of

stress was associated with absences from school and periods in the hospital where he obtained essential medical treatment.

After five years at NYH, Reynaldo left for a position as a professional development coach for science teachers located in schools for students designated as special education. However, his health problems persisted and it was clear that stress was associated increasingly with the production of negative emotions such as anger and sadness, tardiness for work, and absence due to illness. On the advice of his doctor, Reynaldo discontinued his career as a public school teacher and professional development coach because of the stress involved and its impact on his health. He decided to focus on a career as a science teacher educator, where the stress was less, and he perceived he could have greater impact working with teachers who in turn could teach in ways to address the important needs of urban youth.

THE SALIENCE OF MINDFULNESS AND WELLNESS IN SCIENCE EDUCATION

Spirituality, faith healing, and science are central components of Reynaldo's identity in many fields of his lifeworld, including teaching. Even though he experiences contradictions associated with his practices as a medium, faith healer, and scientist it is clear that Reynaldo has endeavored to create coherences between these different ways of being and knowing. Although it is difficult to represent how the epistemological, ontological, and axiological tenets come together in the context of science education, it seems apparent that Reynaldo does not privilege one area over the other and he does not try to keep the areas separate. Instead, he is reflexive about what he does and he reflects on both coherences and contradictions. Nuance is an important characteristic in his efforts to expand the quality of what he knows and does in each of these three and associated areas including roles as educator, parent, and spouse.

Reynaldo regards himself as a compassionate teacher who acts to expand the agency and autonomy of those he interacts with in education and schooling. As is evident in our research, many macrostructures mediate cultural enactment, not just Reynaldo's agency. Science education is mediated by global structures that include tenets of positivism (Kincheloe & Tobin, 2009), individual models of accountability, scientism, and meritocracy (Tobin, 2011). Whereas these global structures do not determine how science education is enacted, they are akin to a social pressure that mediates the practices of stakeholders, including those who are in schools. Identities are constantly changing, responsive/adaptive to the fields in which individuals participate. Identities are radically contingent and might be thought of as a dialectical relationship between want and must. That is, what an individual wants to do or feels he should do is dialectically related to what he knows he must do for particular reasons that are compelling. Axiology is an important issue when identity is considered. For example, Reynaldo is a strong believer in learning science through inquiry. Also, he consciously avoids deficit perspectives of learners and embraces a responsibility to ascertain their cultural capital and allow them to learn through their agency. As a scientist he knows how

important it is to do science and to learn from others who know science, by doing science at their elbow. Because of his own successes due to focus and motivation he knows only too well that individuals can succeed irrespective of the socioeconomic resources of the home. Reynaldo also valued what could be accomplished through research. He had done scientific research and he routinely undertook research on his own teaching and learning of the students. He had empirically validated the use of collective strategies such as cogen and buddy systems. However, Reynaldo was constantly reminded of his responsibility to prepare students for the Regents' examination and the invigilation methods of school administrators and coordinators (e.g., coordinators of science and special education) reinforced a system wide value for teachers establishing control over students and keeping them busy and quiet. This approach to classroom management was widespread throughout the public schools in New York City. Even though Reynaldo knew from his research that collaborative methods were superior when it came to enhancing student learning he also knew he could be "written up" if his classes did not conform to expected/required practices. Nonconformity would lead to transfer and perhaps losing his job. Accordingly, he knew he needed to enact teaching in ways that were structured by dominant expectations for traditional methods. Macrostructures, including policies such as the state and Regents' examinations and the practices of district and school administrators are a dynamic flux that mediates what happens and what is possible.

In the moment, Reynaldo and his students enact science education in the context of collective goals and practices and continuous production of culture that is both structured and structuring. Emotions are constituents of enactment and at times the buildup of negative emotional energy (Collins, 2004) is large in magnitude and extensive, seeping through multiple fields of activity. Contradictions were ever-present as Reynaldo taught, manifesting in negative emotions that included frustration building to anger, and sadness trending toward sorrow. The buildup of negative emotions such as these, due to constantly colliding identities (e.g., formerly a business manager with responsibility for many personnel compared to being required to follow directives from school administrators whose actions violated his professional preferences and values; and being able to communicate with the dead while adhering to tenets of canonical science), became a catalyst for stress and ultimately, poor health. Pervasive presence of high levels of negative emotions changes physiology and manifests in stress-related health concerns that are immediate and ongoing concerns for Reynaldo and his students (see Philippot, Chapelle, & Blairy, 2002). Human conditions, including continuously changing emotions and physiological states, are constituents of identity, which can be considered at multiple levels (e.g., zooming across different intervals of time ranging from hundredths of a second, to minutes, hours, days and weeks). We do not regard factors such as pulse rate, oxygenation of the blood and emotional state as being causally related in simple bivariate ways. Instead we view them as co-occurrent parts of a whole that constantly change as culture is enacted.

Within the context of Reynaldo's lived experiences as an urban science teacher we have learned that identities forged around subject matter knowledge,

competence as a teacher, and goals that are compassionate and focused on social justice are necessary but clearly are insufficient to assure high quality, sustained education. Also, reflexive practices that identify oppressive macro, meso, and microstructures and afford their transformation, though highly desirable, are only part of effectively teaching science. In this case study, Reynaldo's emotions were central to identities, associated practices, and possibilities for the future. As we have reported elsewhere (Tobin, Ritchie, Hudson, Oakley, & Mergard, in press) there is a priority for teachers to learn how to mediate the buildup of positive and negative emotions, in the moment physiological correlates such as breathing patterns and pulse rate and strength, and focus of the mind. Based on this and ongoing research we are acutely aware of the salience of wellness for teachers and students and the central importance of enacted curricula including mindfulness practices (Davidson, 2010) in which teachers and students are aware of, and in control over, factors such as emotions, physiology, and focus.

NOTES

[1] The vertical line (Sheffer stroke) stands for dialectical relationship, which implies that the related entities constitute a whole, are recursively related, and presuppose the existence of one another.

[2] A Statewide examination administered in New York. To graduate from high school a student must pass at least on Regents' examination in science. For many students this is an examination in a course entitled Living Environment. At NYH Living Environment was scheduled to take two years to complete.

[3] A graduate student who was completing the fieldwork required for certification to teach science at high school level. Reynaldo was her mentor teacher.

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11. RECOGNIZING "SMART SUPER-PHYSICISTS": GENDERING COMPETENCE IN DOCTORAL PHYSICS

INTRODUCTION

The study we present here included doctoral students (6 women and 5 men) who, over the course of one year, participated in an ethnographic study aimed at exploring the kinds of subject positions constructed and performed by students engaged in the Discourse of recognizable physicist. We begin with a discussion of the most recognizable subject position in physics–the stereotypical physicist. The stereotypical physicist–the white, geeky, male physicist–is a performance that can be best summarized in this quote from Peter, describing a form of physicist universally recognizable even in the foreign context of a new city:

> Yeah, it's like, it's very cliché, [outside of the convention centre] you see so many people who look like, kind of like these physics geeks. With everyone it's always the same thing...they have this over-precise haircut, or the t-shirt put in the pants and then something, like at least one awkward thing, doing one awkward thing (Interview 1).

The stereotypical physicist described by doctoral students in this study echoes the image depicted in Traweek's (1988) ethnographic study of high energy physicists, the images presented in studies exploring youth's images of scientists (Rahm & Charbonneau, 1997), and those described by undergraduates in physics (Danielsson, 2009; Nespor, 1994; Thomas, 1990). These studies reported on physics communities that constructed a figured world for science that was apolitical, without culture, and dealt with a subject that was abstracted from societal influences such as race, gender, or class. Populating this figured world are recognizable cultural forms for physicists that were dispassionate, rational, and objective, and, overwhelmingly, White, geeky, and male. Accordingly, figured worlds about how a typical physicist looks and behaves have been described as posing limitations for those who do not fit into these normative expectations and constructing a simple binary: woman/physicist. This binary construction has been reported by others, both in empirical studies on gender in physics (Traweek, 1988; Tsai, 2004) and in theoretical pieces (Keller, 1985; 1992; Harding, 1991).

The conundrum this poses for women-identifying students in physics is a question of recognition. When seeking recognition as a physicist, does one risk exclusion if she is not seen as "one of the guys" (Wood, 2004, p. 242)? An excerpt

M. Varelas (Ed.), Identity Construction and Science Education Research: Learning, Teaching, and Being in Multiple Contexts, 157–172.

from an interview with Lily, an experimental physics doctoral student, illustrates this dilemma:

> I don't think most people notice so much [that I'm a woman in physics], so around my home department, I think it is rare for them to even notice that I am a girl. I've had some very strange conversations take place in my presence that normally they wouldn't have happened in front of a girl except that I work with them so, they don't even really register that I am there as a young woman that doesn't want to hear about dates and other exploits, so yeah, they see me as one of the guys…Sometimes it is really strange. (Lily, Interview #2)

Here Lily discusses being seen as *one of the guys* and, thus, at the same time, not being recognized as a woman in physics. Being recognized as one of the guys entails fitting into a figured world of the stereotypical physicist wherein the 'default physics student' is male. This problem has been described previously in doctoral physics cultures (Danielsson, 2009; Tsai, 2004), and, similarly, in campus and workplace engineering cultures (Faulkner, 2007; Henwood, 1998; Tonso, 2006; Wood, 2004).

This study confirms the story presented by others that being recognized as a physicist often entails conforming to stereotypical images of what it means to be a physicist, or, importantly, what one is expected to be as a physicist. However, we wish to challenge the notion that the stereotypical physicist is the only or the most salient subject position a student in physics can perform. Rather, the results of this study demonstrate that students work to perform multiple subject positions in order to gain recognition. Sometimes recognition is conferred upon those who perform the stereotypical image of the physicist, but more often students are recognized as physicists through the performance of various forms of competence, which are not necessarily included in the stereotypical image. These various subject positions that describe 'competent physicists' often interact with the subject positions that describe 'stereotypical physicist,' thus complicating the question of what performances are most recognizable in physics. Typically, the stereotypical physicist is presented as a constraint to women, because it is associated with the supposedly default male physicist. However, when students' performances of competence are recognizable to themselves or others as part of the figured worlds of physicists, they can (in certain contexts) become an affordance, and this can occur whether or not the forms of competence are aligned with performing 'stereotypical physicist.' Thus, we challenge the notion that analysing subject positions and determining their availability to men and women is the most useful method for assessing whether women will manage to obtain recognition as physicists. Rather, we wish to explore the usefulness of a theoretical framework that examines participation as the negotiation of multiple storylines and thus the performance of multiple subject positions as indicators of membership in a physics community and reconsider the current thinking that regards the stereotypical physicist as a constraint to all women participants in physics.

THEORETICAL FRAMING

The *figured worlds* (Gee, 2010; Holland, et al., 1998) of physics are recursively constituted by, and constitutive of, the prevailing storylines and images of how to appropriately perform and be recognized as an acceptable or 'good' physicist. Figured worlds are the "socially and culturally constructed realm[s] of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (Holland, et al., 1998, p. 52). Gee (2010) argues that figured worlds are akin to individuals' taken-for-granted theories about the way things are. They are the stereotypical impressions, simplified stories or pictures of situations with "typical participants, activities, forms of language, and objects and environments" (p. 71). We construct these conventional pictures or stories over time as we participate in various contexts, and then mobilize them to help us understand or act in a given situation. Thus, they are widely circulated and commonly accepted, but oversimplified and formulaic, storylines about being a competent physicist that provide the backdrop against which students learn to become physicists–since being a physicist in a way that is culturally recognized involves more than simply doing experiments or composing a theory. Figured worlds construct subject positions by defining the appropriate content and practices for physicists, that is, they give a sense of what is possible, right, and acceptable for individuals to do and be recognized as physicists. Within figured worlds individuals may perform 'physicist' in a variety of ways that are recognizable within certain social spaces and temporal locations (Holland, et al., 1998; Weedon, 1988).

The concept of figured worlds is useful here because it implies a local understanding of what doing physics entails, while recognizing the situated nature of the local context in a wider sphere of science, physics, gender, and academia. In the figured worlds of physics, some of the recognizable positions have been cultivated in broader cultural contexts (e.g., positions related to race, gender, and class). Others might be more local positions with meanings specific to a community, for example, stereotypical images of geeky physicists (Rahm & Charbonneau, 1997; Traweek, 1988), how to be an academic, or even academic participation in a particular university department.

The way in which individuals negotiate subject positions is referred to as positioning. Davies and Harré (1990) described positioning as "the discursive process whereby selves are located in conversations as observably and subjectively coherent participants in jointly produced story lines" (p. 48). They suggested that positioning can be interactive whereby one positions another, or reflexive, wherein one positions oneself. In both cases, the authors argued that the positioning is not necessarily intentional, but an individual might still invest in a subject position.

When people are positioned or position themselves, they do so by accepting, rejecting, negotiating, or modifying/inventing the subject positions on offer (Holland, et al., 1998). This work is done when individuals make a bid to be *recognized* as a certain kind of person, thus taking up a storyline of physicist in an appropriate and acceptable way (Gee, 2005). Using Gee's concept of recognition, a successful bid to be recognized as a certain kind of person (i.e., physicist) by

meaningful[1] others, and especially by meaningful scientific others, is a means by which students may begin to think of themselves as scientists and make choices to pursue that kind of subject position in the future. Similarly, Carlone and Johnson (2007) have taken up this notion of recognition and suggested that while criteria for credibility or competence may vary based on context, a key component of science identity is that these performances are recognized as credible both by the individual doing the performing and by other recognized members of the field. Thus, a salient analytical category for this chapter is the positioning work that participants did to be recognized as physicists. This work involved a complex negotiation of the subject positions offered and taken up, and included performances of various forms of competence, gender, and stereotypical images of physicists.

METHODOLOGY

The stories presented in this chapter emerged from selected participants in a study of physics doctoral students and serve to illustrate how the figured worlds of physicists construct a complex terrain for students to negotiate as they make bids to be recognized as physicists. These stories not only share a view into physics that disrupts common-sense notions of the straight forward relationship between women and femininity, they also speak to the varied ways that doctoral students' identities as physicists "are created by experiences of being positioned" (Holland & Leander, 2004, p. 127).

This study entailed 4 months of field observations in lab meetings, seminars, workshops and supervisor-student meetings of three groups conducting research in different sub-fields of physics (nano-physics; astrophysics and string theory). The stories presented in this chapter were assembled from a combination of interview data, photo-journals and researcher field notes. Participants were asked to take photographs of scenes in which they felt like a physicist or did not feel like a physicist and to keep a journal explaining why they took the photographs and what kinds of stories they told about being physicists. Two interviews were conducted with each of the 11 participants, involving life-history and photo-elicitation to construct narratives of experience that together with the photo-journals and researcher field notes told stories of who could be physicists. A thematic analysis of these narratives yielded three broad analytic categories or stories that helped us to describe the figured worlds of physicists and present stories of positioning that were relevant in this context. Stories of positioning that revealed positive associations with various subject positions constructed within the figured worlds of physics were determined by the degrees to which participants expressed episodes of recognition and positive emotional energy. Indices for recognition (by self and by meaningful others) were established in accordance with those used by Carlone and Johnson (2007). Positive emotional energy has been described as a rush of good feelings rising from a successful interaction, which we have interpreted to include relations between participants and other individuals as well as artifacts or objects that populate the figured worlds of physics. Collins (2004) describes this

positive emotional energy as persisting beyond the interaction and recursively shaped in continued interactions. Others have assessed positive emotional experiences on a micro-level by assessing body movement, eye contact, posture, voice rhythms and speech patters (Elmesky & Seiler, 2007). We assessed positive emotional episodes through interview talk about how doing physics or interacting with others was said to make participants "feel" a certain positive way.

RESULTS

Figured Worlds of Physicists

One of the most common ways of being recognized as a physicist is through the performance of the stereotypical physicist. In this storyline, a stereotypical physicist is hard-working and absorbed in his/her projects and, thus, not concerned with appearances or social conventions. Laura, a theoretical physics student, illustrates this in the following excerpt from a journal entry:

> On days when I am busy with physics, in the middle of a project or rushing to meet a deadline, I am very likely to leave the house without putting a piece of jewelry or any makeup on, even without combing my hair, because work is more important. I am likely to have dark shadows under my eyes. I know a girl who dresses in skirts and heels when at summer schools, but told me she never dresses up around her supervisor, so that he will think she is always working. (Laura, Journal entry p. 3).

According to this storyline, the performance of physicist that seems most likely to be recognized is one that conforms to the masculinity associated with the stereotypical physicist, or one that is disassociated with normative expressions of femininity. Thus, this subject position of stereotypical physicist offers limited recognizable ways for students to perform physicist.

The performances associated with images of the stereotypical physicist also intersect with other ways of being recognized as a good physicist. We have characterized these as *technical competence, analytical competence*, and *academic competence*. Each of these forms of competence was identified from the ways participants talked about the skills and habits that they recognized as belonging to good physicists. Generally, these emerged in response to questions about what makes a good physicist–questions about whether and how the participants could identify good physicists, or about what they would need to do, or to be, in order to consider themselves recognizable as good physicists. Carlone and Johnson (2007) described competence as a feature of scientific identity that can be represented as degrees of achievement measured by grades or diplomas. However, among doctoral students, grades are not calculated and competence is discussed as highly specialized sets of skills that are sometimes specific to disciplinary subfields and are recognizable through performances (lab work, writing, communication, teaching, calculating, etc.) and drawn from the larger figured world of academia in the case of academic competence. These additional forms of recognition were also often associated with stereotypical and appropriate ways to do good physics and be

a good physicist–that is, a good physicist often displays competence in one, or a combination of some, or all of the following three areas: analytic, technical, and academic competence.

Analytic competence was centred on logical reasoning, and had strong connections to notions of intellectual elitism. Stereotypical descriptions of analytical competence included problem solving skills and the desire and ability to apply logical arguments to everything, including non-physics situations. Analytical competence was associated with high intelligence, highly valued, and was used as a strong indictor for delineating between physicists and non-physicists. Not surprisingly, the counterpart to analytical competence, namely *technical competence*, emerged as another related set of behaviors or norms recognizable and valued in the physics department. Most particularly, technical competence was espoused as a necessary recognizable feature of being an experimental physicist, and, thus, had some disciplinary specificity. Technical competence was associated with the handling of machinery, with an ability to fix machines or understand how they work, and with creativity and physical skill. While the technical and analytical competencies that are often associated with physics were discussed by many of the participants in the study as necessary characteristics to be recognized as good physicists, one area of competence emerged as important that was not directly related to physics. Many participants talked about being a good physicist in ways that were aligned with the expectations of academia, in general. *Academic competence* including skills like communication (writing and presenting), teaching, and competitiveness emerged as a specific skill set generally associated with physicists in the academy.

Intersecting Storylines: Stereotypical Physicist and Forms of Competence

The forms of competence identified in the stories of the physics doctoral students intersected in different ways with the figured world of the stereotypical physicist and acted as both affordances and constraints to women physics students. Here we discuss the various forms of competence and provide some examples of forms of positioning that women doctoral students engaged in to gain recognition as physicists.

Analytical competence. Analytical competence has been associated with physics as a discipline that is very difficult, requiring a great deal of intelligence, and constituting an elite practice. It is part of the common cultural understanding of theoretical physics as a hard science and to theoretical physicists as highly intelligent people. Analytical competence has a strong association with what Wajcman (1989) referred to as a "professionalized, calculative rationality" (p. 144), held by theoretical specialists whose close relationships to machines and formulas has "cut them off from other people, and they rely on the [theorist] subculture for their sense of identity" (p. 144). This characterization of analytical competence aligns it quite closely with the stereotypical physicist, and produces subject positions for analytically competent physicists that are imbued with stories

of social ineptitude, disheveled appearance, and a form of masculinity that is derived not from the dominant hegemonic form, but rather from the perceived 'hardness' of the discipline. Harding (2006) argued that, "objectivity and rationality…are persistently linked to certain models of [dominant Western] masculinity" (p. 83). Part of the problem with labeling rationality as masculine is that it enshrines masculinity in normal science, and causes the institution of science to take up masculine practices attributed to males (Keller, 1985). This form of competence, along with the technical form of competence, has been previously described by Danielsson (2009) as a Discourse model for doing physics that is strongly related to hegemonic masculinity.

However, women participants did not cite this as being either detrimental or a deterrent to their progress in physics; rather, they offered several counter examples. Although Laura described the intersection between the stereotypical physicist and analytical competence in the following way: "Theoretical physicists who get wrapped up in their work often look absent-minded because they don't pay much attention to their appearance" (Laura, Journal entry p. 3), she likewise argued that analytical competence was the cornerstone of doing good physics and rejected the association it had with masculinity, suggesting: "a good scientist must be rational and objective, and this is not me accepting that science is masculine" (Laura, e-mail communication, January 17, 2010). Similarly, Lily associated a positive emotion to successfully solving an analytic problem and feeling like a "smart super-physicist," a subject-position that she ably took up, in addition to demonstrating technical and academic competence in other areas. Thus, while the storyline of the stereotypical physicist intersected strongly with that of analytical competence, certain women physics students did not view this as a constraint. Rather, these women sought to perform analytical competence either through enacting the "smart super-physicist" subject position, or through performances of the stereotypical physicist subject position, or both. Often, as Laura described above, enacting a recognizable performance as an analytically competent physics student entailed performing the stereotypical physicist subject position.

Technical competence. At its core, technical competence is founded on an association with handling of machinery, with an ability to fix machines or understand how they work, and with both creativity and physical skill. Wajcman (1991) suggested that control of technology is often associated with archetypal hegemonic masculinity. She described this form of masculinity as based on physical toughness and mechanical skills and further suggested, "all the things that are associated with manual labour and machinery…are suffused with masculine qualities" (p. 142). Wacjman argued that central to the construction of the link between masculinity and technical competence was the absence of stereotyped femininity. Part of what makes the intersection of the stereotypical physicist with competence so important, is that it compels us to construct assumptions about what kind of person engages in physics. Constructing technical competence as intersecting with the "shop floor" masculinity, and simultaneously as notably distinct from stereotyped femininity, leads to recognizable subject positions for

physicists that exclude women. Such a construction was seen most clearly in a story told by Lily, an experimental physics doctoral student doing research on a scanning tunneling microscope (STM).

In her photo journal, Lily provided a number of images of her manipulating a sample in the STM, indicating that manipulating samples has become the foundation of her work in the lab (see Figure 1). In an interview, Lily referenced the limitations that requirements for physical skill pose for individuals who are not big or strong enough to manipulate the instrument used in her line of work. To illustrate this, Lily described a trip to a lab in Germany where the STM she had become accustomed to was built differently:

> **Lily**: I actually, I spent a month in Germany with another research team, and they had an instrument by a different company that's based in Germany, and everything was really big. I had to stand on things to be able to see and reach, and I physically couldn't do a lot of the transfers by myself because I just couldn't, I didn't have the arm span to reach.
> **AG**: Is it made for bigger people?
> **Lily**: Well, this is my theory. It's made by a German company and a lot of German people, especially men, are like, large, and our instrument is made by a Japanese company, and Japanese people are quite small. I didn't clue in until I came back home and everything was easy, and in reach again and I was like 'I wonder' but you know, it could very well be.
> **AG**: Is there a reason why it would be made bigger? Or it just was.
> **Lily**: No, I think it just was. There was no real necessity for it. It was essentially the same kind of instrument, but in a different country.
> (Lily, Interview #2)

In this case, the design of the STM delegated gendered roles, actions, and responsibilities to the physicists who used it. As a smaller-framed woman, Lily was limited by her stature in her work with the STM, a material resource that is accessible to men of large stature. The engineering of an instrument such as the one manufactured in Germany that is too large for a woman, slight man, or person with a disability, relegated the use of the instrument to only large men (or exceptionally tall women). This created a subject position for *physically skilled physicist,* which was constrained, though, to those individuals whose dimensions were appropriate to the instrument. This also potentially indicated that the STM architects designed the instrument with a certain gender in mind, a reality noted by Berg and Lie (1993).

Wacjman (1991) suggested that technical competence is a form of masculinity "based on physical toughness and mechanical skills" (p. 143). She also pointed to machine-related skills and physical strength as being measures of masculine status. In this case, assumptions about what kinds of people would be using the STM figured into its design. Thus, we are able to observe how the storyline of the stereotypical physicist bears material effects for those who seek to be recognized as physicists using the indices of technical competence.

Lily's method of subverting this hegemony was to position herself as expert in preparing the sample and accessing the vacuum chamber with her smaller hands. As a woman with a smaller frame and hands, Lily was able to develop an expertise outside of the traditional realm. In this improvisational act, Lily redefined technical competence in a powerful way, through her performance of a physically-skilled physicist on an instrument that was not intended for use by someone like her.

Academic competence. Perhaps the most surprising finding emerging from the participants' descriptions of forms of competence was the strong association between academic competence and social skills. Academic competence was discussed by most participants and was centered on competence in communication with others. Communication competence included the ability to either teach others, or share findings in social environments such as conferences, or share findings through written documents such as article publications. The participants who mostly espoused the importance of academic competence came largely from astrophysics. This was not surprising given the high degree of collaboration and competition that marks the social structure of that subfield. All of the participants in this study had to interact with others, often in large collaborations, and thus, the ability to communicate using the language of the discipline was of utmost importance. However, cultural stereotypes of physicists have often described them as socially inept, independent workers, and reclusive (Danielsson, 2009; Rahm & Charbonneau, 1997; Traweek, 1988). Thus, the salience of this competence fell in contrast to the stereotypical physicist, and in that way academic competence differed from analytic and technical competence, which aligned with the stereotypical physicist.

Physics generally falls at the technical end of a technical-social dualism that constructs fields like physics and engineering as focused on problem-solving and building, with little emphasis on social skills (Faulkner, 2007). However, as Faulkner noted, this technical-social dichotomy is a false one, based largely on gendered interpretations of the field, assuming strong associations between femininity and the social, and masculinity and the technical. The data collected in this study supported the challenge to the dichotomy that Faulkner posed, and extended it by suggesting that not only are physicists actually engaged in institutionalized social activities, they also value the acquisition of social skills and see this as a competence that is necessary to the academic physicist. Social skills including communication were particularly valued among doctoral physics students intending to pursue academic careers in their subject. This emerged as a counter example to reports that physicists tend to be individualistic and asocial (Traweek, 1988). Many participants, both men and women, described valuing social skills, and there were examples of women who saw themselves as lacking the social skills of academic competence, despite the strong marking of sociality as feminine (Faulkner, 2000).

However, while the breakdown of the common technical/social dualism might be regarded as an affordance for women students, the style of communication in academic physics that was most valued had gendered constraints. Carol, a doctoral

student in condensed matter physics, discussed the difficulty of learning the language of physics, but more particularly, she struggled with the style of presentation of information that was valued in her physics community. Carol found that learning the technical language of physics–the jargon, as she referred to it–was something that she struggled with, and interfered with her ability to interact with colleagues, especially at conferences. She saw learning the language of physics as important to gaining recognition from the physicist community:

> I think that you should [learn the jargon] if you want to be seen as really good at what you do. If you want to be an experimental physicist, I think you should really try hard to make sure you know all of those words. At least the ones that are relevant to your own research that is, so I am trying all the time to learn all of these words. I do think it is important. It is just something that I find difficult. (Carol, Interview #2)

While her aversion to learning the technical language of the discipline might be attributed to an insufficient enculturation in the linguistic practices of physics, further discussions with Carol indicate that there is a gendered aspect of this positioning as well. Carol indicated this when she discussed the difference between herself and her boyfriend, also a doctoral student in the physics department. Carol suggested that her boyfriend (who plans on pursuing an academic career) is good with people, whereas she does not feel that she has the "personality" to engage colleagues and students in her field:

> It is just your personality, and he is very good with people and I don't know, he can talk to anybody and get them really excited. Whereas I find that if they are interested, then I can talk to them but if they are not interested, then I don't know how to make them suddenly become interested. But I am better at some things, like I am better at explaining things in a laymen terms whereas he uses the language of the–whatever–so that is harder to understand him. But that goes the reverse way when we are with other academics, he speaks the language and I don't, you know. (Carol, Interview #1)

Here, Carol constructs a gendered notion of charisma as a valued form of communication in physics. Charisma as a personal communication style is one that is typically associated with masculinity (Holmes, 2006). Moreover, her suggestion that other physicists would be more engaged by her boyfriend's explanations of physics phenomena than by hers resonated with reports that scientists who display more prototypically masculine characteristics are often listened to more closely and taken more seriously than women in scientific venues (Conefrey, 1997; Hasse, 2002). In an ethnographic study of a physics classroom, Hasse (2002) found that the language that men used to communicate in physics was jocular, entertaining, steeped in references to science fiction, and often excluded women. Conefrey (1997) demonstrated through conversational analysis of laboratory interactions the many ways in which the men in the lab used jocular comments and jovial conversation style, not only to hold the attention of other members of the lab, but also to undermine the credibility of women speakers at lab meetings and

presentations. Thus, participants' figured worlds of academic competence present a contradiction: On one hand, they challenge the technical/social dualism described by Faulkner (2007) and present us with subject positions for physicist that do not intersect with the stereotypical physicist, but rather value social skills, such as communication. On the other hand, the figured worlds of academic competence reproduce gendered forms of communication that are valued in professional environments (Conefrey, 1997; Ingram & Parker, 2002). While Carol generally achieves recognition through her performances of other forms of competence, her performance of academic competence appears to be hampered by the gendered styles of communications that she deems recognizable in physics, and by her discomfort with participating in the practices associated with this particular form of competence.

Repositioning "Subject Positions" in Identity Research

Research examining the availability of subject positions for women and girls in science has tended to explore how these present a limited number of ways of being scientists, only a few of which are available to girls and women (Henwood, 1998; Hughes, 2001; Walker, 2001). We find this approach troublesome for two reasons. First, assuming that subject positions are unavailable to women because of their gendered connotations implies that women and girls choose not to (or are unable to) take up subject positions because these positions would be inconsistent with normative expectations for gender roles. Second, there is an assumption that subject positions in physics are only possible or available if they are already out there and available for individuals to take up or refuse, thus ignoring the innovative, performative possibilities illustrated in this research.

A more useful perspective might be to regard subject positions in physics as being constituted through individuals' performances and galvanized through the recognition of these performances, rather than being solely reliant on what exists a priori. In doing so, we may begin to see how women perform physics in varying degrees of stereotypical or recognizably competent ways and then explore how the participants' figured worlds that make up understandings of stereotypical or competent physicists may render these performances acceptable or not. A framework that addresses ways in which individuals work to be recognized as physicists and how their performances are recognized, or not, provides a more complex picture of gendered participation in physics. For example, one participant, Ruby, demonstrated that performing 'stereotypical physicist'–a subject position that in most circumstances might be seen as a constraint to women students making bids for recognition as physicists–was actually an affordance when her other performances of competence were not deemed appropriate or recognizable.

Ruby was a doctoral student in physics who had difficulty with health issues that prevented her from participating in many of the daily activities in which doctoral students engage (e.g., lab meetings, departmental seminars, informal networking). In many ways, Ruby did not recognize herself as an astrophysicist, and expressed that she was not recognized as such by members of her group.

Looking at a photograph she took of the seminar room where her team meetings are held, Ruby said:

> Yeah, like I feel so out of place when I sit in a place where you know, the other people from the group are. They all know so much more than me. I feel out of place, but it is all my fault. I am the one who did it, so that they know more than me. So yeah, that room makes me feel guilty. (Ruby, Interview #1)

In our interviews, Ruby repeatedly made statements such as these, indicating that she felt out of place and marginalized by the practices of her research group. Ruby consistently positioned herself outside of the three forms of competence. She explained on several occasions that she did not feel that she had the "fix-it" knowledge (technical competence) that many of her colleagues had, and she lamented that although she taught physics courses, she always felt that she was one day ahead of her students, and could not remember basic principles of physics (analytical competence). In addition to not being recognized by the indices constructed within the storylines of analytical and technical competence, Ruby also considered that the academic competence she brought to her work (methodical working and attention to detail) were not recognized (and thus valued) by her research group. Ruby ultimately finished her doctoral dissertation and defended it successfully, although she did not achieve recognition as a physicist by drawing upon the indices of these three forms of competence.

Ruby, however, did achieve recognition as a physicist on occasion through other means. Perhaps ironically and counter to the prevailing literature, one way that Ruby was able to gain recognition was through a performance recognizable as a stereotypical physicist, which simultaneously asserted her difference to other women. Discussions with Ruby often turned to descriptions of acceptable gender performances within the context of the physics community. During our interviews, Ruby positioned herself as a physicist by suggesting that she looked like a recognizable physicist:

> In general, I don't care what I wear, and lots of physicists don't care what they wear–or some of them, anyway. Girly girls are something else, I can't stand girly girls, I don't think you are a girly girl, don't worry [laughter]. (Ruby, Interview #2)

In her performance of the stereotypical physicist, who should not care about what she wears (see Laura's description at the beginning of the chapter), Ruby not only positioned herself as a recognizable physicist, but also positioned herself against the so-called girly-girls who perform stereotypical femininity (Wajcman, 1991). By positioning herself in opposition to girly girls, Ruby asserted her difference to what she considered a gender performance incompatible with physics, thus aligning herself with what she determined was an appropriate way to be a physicist. Later in the same interview, Ruby reasserted the incompatibility of stereotypical femininity and physics by drawing on the discourses of logic and

rationality (related to analytical competence) to explain how there was a contradiction between physics and girly girls:

Ruby: I just find that physics and girly girl–there is a contradiction somewhere.
AG: OK, I want to explore that somewhat though, like what, why is there a contradiction between girliness and physics?
Ruby: Well there is a contradiction, like, the wearing high heels thing. If you are [a] logical person who is able to do string theory, then you should realize that you are hurting yourself by wearing high heels. Um, what else is the contradiction? It is all the scale of priorities where people have different priorities and I suppose they are allowed to have their appearance as high a priority as their research, so why is that bothering me? I don't know but it is bothering me for sure.
(Ruby, Interview #2)

For Ruby, it was difficult to see how women who dressed in more normatively feminine ways could be recognizable as both stereotypically feminine and physicists at the same time. Rather, Ruby saw this form of femininity as incompatible with physics, and instead sought alignment with physics through her performance of the stereotypical physicist. Of great interest here is that Ruby did not regard the subject position of stereotypical physicist as incompatible with her construction of femininity.

Ruby acknowledged that there are different ways of performing femininity when she referred to girly-girls, but placed them outside of physics when she referred to them as "something else." Thus, Ruby positions this kind of femininity as counter to the logical thinking associated with the figured worlds of physics and an unrecognizable subject position within this figured world. In one way, Ruby's construction of the girly-girl, (or the non-physicist woman) in opposition to physicists serves to galvanize the association of masculinity with the figured worlds of both the stereotypical physicist and competence in physics, and reaffirms the physicist/non-physicist woman binary discussed at the beginning of the chapter. However, another reading of this might be that Ruby's observations point to the construction of local and context-dependent femininities, some of which do intersect with the figured world of the stereotypical physicist, and are thus recognizable in the local context in which they are performed.

AG: Do you feel like you are one of those people who are–
Ruby: Yeah, I don't mind whistling in the corridors, sometimes when the corridors are empty in the physics building, I try to do cartwheels. And I wear sandals, and I don't exactly mind that. I am wearing a slightly older t-shirt, so appearance eccentricity and sometimes behavior eccentricities, I sometimes do horde them, so yeah, so I sort of am part of those people, so yeah.
(Ruby, Interview #2)

We might be tempted to interpret this as the binary exclusion of femininity from physics (and thereby selective inclusion of masculinity in physics), but Ruby's behavior and ideas around gender performances might also indicate the construction of new and context-dependent femininities in physics. By enacting the performance of stereotypical physicist through her appearance and behavior, Ruby found a way to achieve recognition as a physicist, and still as a woman, despite not being recognized according to any of the forms of competence associated with the figured worlds of physics.

CONCLUSION

We have presented evidence that recognition is a key component to constructing a physicist identity and that recognition can come through performances of competence or performances of stereotypical physicists. In doing so, we have challenged the notion that subject positions for women in physics are limited to those that incorporate stereotypical notions of femininity. At the same time, we presented the idea that the construction of the stereotypical physicist might be not always be a storyline that alienates women from physics, despite the emphasis that this storyline places on masculinity and its implied association with men. This finding lends further evidence to claims that women are not necessarily "turned off" by physics because of its associations with masculinity (c.f., Gilbert & Calvert, 2003; Henwood, 1998; Walker, 2001). Thus, we draw attention to the necessity to decouple the notion of masculinity and men from physics, and to rather emphasize the emergence of various forms of localized masculinities and femininities in physics, which may be taken up by both men and women participants.

Our findings also draw attention to the various intersecting competencies that doctoral students identify as necessary for recognition in the figured worlds of physics. By focusing our attention on descriptions of competence and the ways in which these performances are constructed in relation to masculinities and femininities, we may begin to better understand the gendered construction of physics practices and the various innovative ways that women (and men) engage in these practices in order to gain recognition. In describing the ways in which gender constructs what is an appropriate and acceptable performance of technical, analytical, and academic competence, and of the stereotypical physicist, we also discussed the many ways in which women sought to reconfigure these notions of competence and behavior to achieve recognition. However, the 'problem' still lies in the construction of physics as a gender-neutral discipline, which is tolerant of a range of expressions of masculinities, but permits only limited forms of expressions of femininity (Tonso, 2006; Danielsson, 2009). Research addressing the so-called problem of women in physics needs to contend with this reification of the problem and find ways to understand how locally different, and often shifting, constructions of masculinities and femininities in the physics community are constituted in ways that decouple masculinity and femininity from men and women. This might help us to further explore how physics students navigate the storylines of physics in innovative and sometimes transformative ways, at the same

time that it provides a more complex picture of the field of physics activity, and serves to challenge dominant narratives about the gendering of competence.

NOTE

[1] Here we use the term *meaningful* in the same sense as Carlone and Johnson (2007), that is, "people whose acceptance of her matters to her, as a science person" (p. 1192).

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12. CONSEQUENTIAL VALIDITY AND SCIENCE IDENTITY RESEARCH

INTRODUCTION

While my research focuses on the science identities performed by women of color, my overarching concern is with social justice. Thus, the first thing I want to ensure about my own work is that it can be used to increase equity, in or out of science, in some way. I think of this as ensuring that it has consequential validity. Consequential validity usually refers to whether test score use is valid (Popham, 2005). When the social consequences of a test are congruent with what the test is actually able to measure (so that people think the test use is "fair"), the test has consequential validity.[1] In thinking about my own work, I borrow this concept, but broaden it to apply to qualitative research. With testing, the concern is that test scores might be put to inappropriate use. With my own research, my concern is more that it cannot be put to use at all. Thus, to explore the consequential validity of my research, I ask questions like: To what social purposes can it be used? Does it identify strategies to bring about greater social justice in or beyond science?

In this chapter, I explore the consequential validity of identity research in science education. I first question whether there are inequities in science; because if not, then of course there can be no consequential validity to this research, if, by consequential validity, I mean the promotion of social justice. I then pose three tests of consequential validity for identity research in science education, and examine each of them at some length. This exploration leads me to conclude that we need to look at not only science identities performed in particular contexts at particular times (which I call snapshot identities) but at how those identities string together into trajectories over time (time-lapse identities). Finally, I present some results from my own research, which suggest the power of using time-lapse approaches to study identity trajectories.

ARE THERE INEQUITIES WITHIN SCIENCE?

To explore questions of consequential validity, I first have to determine what inequity might look like in a science setting. Is science currently marked by injustice? I see two useful ways of looking at this question. First, there is the problem of poor science literacy among particular groups; second, of under-representation of certain groups in the ranks of practicing scientists.

M. Varelas (Ed.), Identity Construction and Science Education Research: Learning, Teaching, and Being in Multiple Contexts, 173–188.

Inequitable Access to Scientific Literacy

Science literacy allows people to understand and improve their lives, and to solve problems that concern them. Lack of access to useful, powerful science education can affect individuals' and communities' health, economic opportunities, and quality of life. National Assessment of Educational Progress (NCES, 2009) and Advanced Placement (College Board, 2010) data (Table 1 and Table 2 respectively) make it clear that certain kinds of students in the U.S. have far greater access to the kind of rich science curriculum which students need to develop science literacy, as can be seen in the following tables.

Table 1. 2009 scale scores, science, National Assessment of Educational Progress (NAEP), by race

	White	*Black*	*Hispanic*	*Asian/Pacific Islander*	*American Indian/Alaska Native*
4th grade	163	127	131	160	135
8th grade	162	126	132	160	137
12th grade	159	125	134	164	144

Table 1 indicates that in every grade level, Black, Hispanic and American Indian students score considerably lower in science tests than their White and Asian counterparts. Note that NAEP is administered to a random sample of students.

Table 2. 2010 average Advanced Placement (AP) science scores, by race[2]

	White	*Black*	*Mexican American*	*Other Hispanic*	*Asian*	*American Indian*
Biology	2.76	1.64	1.69	1.96	3.06	2.05
Chemistry	2.77	1.70	1.75	2.02	3.15	2.07
Physics B	2.94	1.81	1.90	2.12	3.03	2.41

The AP exams, on the other hand, are taken by self-selected students, who have spent most of a school year preparing, in class, for these tests. Nonetheless, gaps persist across race.

I do not believe these numbers reflect differences in aptitude for science. Rather, they indicate inequities in opportunity to learn science. For instance, Black, Latino, and American Indian students in the United States frequently attend schools with fewer financial resources than those available in schools which serve mostly White children (Kozol, 2005). They are likely to attend schools that are, de facto, segregated. For instance, in 2005–06, a typical White student attended a school which was 77% White (though White students made up only 57% of the school-age population); meanwhile, a typical Black student attended a school which was 52% Black and/or Latino (Lee & Orfield, 2007). According to the most recent data collected by the U.S. Department of Education's office of civil rights, 500,000 schoolchildren attend US high schools

which do not even offer Algebra II; two million attend schools which do not offer calculus (Shah, 2011).

These patterns–unequal access to resource-rich schools, coupled with unequal performance on standardized science tests–convinces me that certain kinds of people in the US do indeed have inequitable opportunities to develop scientific literacy.

Inequitable Participation in Scientific Careers

This opportunity gap is coupled with gaps in who becomes a scientist. Using data available from the National Science Foundation (NSF), I calculated that, as of 2006 (the most recent data available from NSF), women continued to major in science in smaller proportions than men. Using raw data provided by the National Science Foundation (NSF, 2010), I calculated the percent of White, Asian, Black, Hispanic and American Indian men and women (the categories tracked by NSF and the terms they use) majoring in science, *as a percent of the number of people in each of these groups graduating from college overall*[3] (Table 3).

Table 3. Percent of college graduates in each group, 1997–2006, who majored in science

	White	*Asian*	*Black*	*Hispanic*	*American Indian*
Male	14.7	24.4	12.6	12.7	14.6
Female	9.0	18.3	9.2	8.1	9.0

As you can see, women continue to major in science in lower proportions than men in every racial group tracked by NSF.

I also calculated the representation of the same groups in the ranks of practicing scientists.[4] I used employment data from 2008 (the most recent data available), and calculated the representation of individuals of each racial group tracked by NSF as a percent of the total number of practicing scientists at each degree level (NSF, 2011). Note that the numbers in Table 3 represent percents within each race and gender; the numbers in Table 4 represent percents within each employment category.

Table 4. Percent of all employed scientists, by race, gender and highest degree earned, 2008

	White		*Asian*		*Black*		*Hispanic*	
	Women	*Men*	*Women*	*Men*	*Women*	*Men*	*Women*	*Men*
BA/BS	32.8	48.1	5.3	3.8	1.8	2.0	2.5	2.8
MA/MS	28.9	50.0	8.5	6.5	1.9	1.2	1.9	1.2
Ph.D.	18.8	54.2	6.6	15.1	0.4*	1.5*	1.1*	2.2

Note. Row totals do not add to 100% because of rounding and suppression in the original data set. American Indian values are omitted. All but one value was unavailable because NSF suppressed the numbers "for confidentiality reasons." *These values are inaccurate because some of the measures they rely on were omitted by NSF in calculations.

I assume that interest in and aptitude for science are evenly distributed among the population. I have no proof of this; however, this seems more likely than the existence of a race- or gender-linked genetic component to science talent. Given this assumption and the numbers I have laid out about access to quality science education and about participation in science at the university and career level, I am further persuaded that serious inequities exist in science.

Why Inequities in Science Matter

However: Inequities exist all over the place, in many disciplines and contexts. Since my first concern is not science but social justice, why should I be particularly concerned about inequity *in science*? First, scientific knowledge and ways of thinking are inherently valuable and (I believe) satisfying; they help us understand our world. Further, they allow us to solve problems in our own lives and the lives of others. If the likelihood that a child will acquire scientific knowledge and skills is a function of the school they attend, or can be predicted by the color of their skin or the economic status of their parents, this is a cause for great concern.

Second, I am concerned with the impact *on science* of lack of diversity among science practitioners. Scientists ask questions that can either advance the common good, be neutral, or harm humankind and the environment; scientific work is inextricably bound up to concerns with social justice. Furthermore, scientists' life experiences matter in answering those questions; if we want the best questions asked, and the most creative answers to those questions, as Sandra Harding (1991) has pointed out, we need scientists with the widest possible pool of experiences to draw from. Thus, it matters who does science. Further, there is a small but growing pool of research suggesting that many Black, Latino and American Indian students are drawn to science for its altruistic possibilities (Carlone & Johnson, 2007; Ceglie, 2011; Haun-Frank, 2011; Johnson, Anderson, & Norlock, 2009). These studies do not compare the motivations of people of color with those of white people studying science, but they suggest nonetheless that increasing the diversity of practicing scientists is a way to advance the common good.

Finally, I think it is valuable to study science because science is a high-status arena. This matters for two reasons. More obviously, social justice demands access to a well-paid, well-respected position should be determined by a person's scientific ability, willingness to work hard, and interest, not by their gender, race, or economic background. Further, the high status of science, coupled with the NSF statistics I lay out above about who actually does science, makes science a superb place to study power. What better place to examine the moment-by-moment dynamics through which an important social setting continues to be dominated by people of particular races, genders, and economic backgrounds than the white, male domains of science?

TESTS OF CONSEQUENTIAL VALIDITY

I am persuaded that science settings are plagued by inequalities and, thus, studying these settings have the potential to further social justice. So the next question is: How? I can see three tests that can be used in order to determine whether a study about identity in a science setting advances social justice and, thus, has consequential validity; I am sure there are more.

1. Does a study help us understand how to create classrooms where students (especially students from underrepresented groups) can acquire a foundation of scientific literacy?
2. Does a study help us understand how students persist in science, again particularly those students who come from under-represented groups?
3. Does a study help us understand power in general, both how power gets apportioned so that it follows typical patterns and also approaches for apportioning it differently?

I examine each of these tests below.

Increasing Access to Scientific Literacy

This is the easiest test to apply. Does an identity study tell us how to create a classroom or out-of-school science setting where students improve their scientific skills or knowledge? For instance, do students feel that scientific skills and knowledge are useful, that they are efficacious users of these things, that science is a legitimate endeavor for them? Does a setting support students in developing an affinity for science, in thinking of themselves as "science people?"

Identity studies which have consequential validity through increasing access to scientific literacy might look at the way a teacher views herself in a science classroom, how objects are used in a science setting, how time is apportioned, the kinds of activities available, the student identities celebrated or marginalized. Ideally, teachers, parents, or people designing science programs should come away from a study like this with either concrete ideas they can put into practice or some solid theoretical foundations out of which they can generate concrete ideas. This can include both ideas of what to do and what not to do.

Understanding Persistence in Science

We have a rich research base on the kinds of settings where students from under-represented groups in science (girls of all races; Black, Latino and American Indian boys; students who do not speak English as their native language) develop a science identity (see, for instance, Barton, 1998; Barton, Tan, & Rivet, 2008; Basu & Calabrese Barton, 2007; Brickhouse, Lowery, & Schultz, 2000; Brickhouse & Potter, 2001; B. Brown, Reveles, & Kelly, 2005; Buxton, 2010; Carlone, 2003; Carlone, Haun-Frank, & Webb, 2011; Rahm, 2007; Reveles, Cordova, & Kelly, 2004; Tan & Barton, 2008; Upadhyay, 2010; Zahur, Barton, & Upadhyay, 2002).

These studies meet my first test of consequential validity beautifully. But, because they are snapshot studies, of short-term identity performance, they cannot address my second test: helping us figure out how to support individuals who are trying to persist in science against the odds.

We have another literature base on individuals from under-represented groups who manage to persist in science-based fields (see, for example, S. W. Brown, 2002; Carlone & Johnson, 2007; Ceglie, 2011; Johnson, 2007a, 2007b; Johnson, Brown, Carlone, & Cuevas, 2011; Ong, Wright, Espinosa, & Orfield, 2011; Russell & Atwater, 2005; Seymour & Hewitt, 1997; Tonso, 1999, 2006). These studies are more long-term in nature, often with a focus on the characteristics individuals cannot control (levels of family and school support, for instance), on the strategies they can control (approaches to working in groups, use of resilience) and on the obstacles they face. This body of work generally has a specific focus on rectifying the under-representation of particular groups in science.

What we need is a way to connect the two: the short-term and medium-term identities manifested in science learning settings and the long-term trajectories of individuals who have been able to enter into science-based professions. Without this time-lapse view, our understanding of classroom-based identities is limited. We may gain insight into how to create a great science classroom or program, but we do not know how to go from there to the next level, namely preparing individuals who will be able to persist and become scientists or acquire the skills and mind-set to use science as a tool in their lives.

In my view, I have been assuming that for a science-focused kid from an under-represented group to grow into an adult practitioner of science, the following takes place: The child forms a strong affinity to science, and we can see that because she manifests a positive science identity in all sorts of settings; because of this affinity and this strong identity, she acquires a lot of science skills and knowledge and also sees herself as belonging in, and thus pursues, science settings. What was initially a series of science identities in different settings has become a science trajectory. Thus, studying science identity in a particular context is a first step in understanding how individuals persist in science. But: Am I right? I do not know because of the nature of the data; we have snapshots from the various stages in this imagined trajectory but we do not know if they actually are connected or not—or if the people who are at each stage actually got there in some very different way than the way I have mapped out here.

I am particularly troubled on this question because of a study of the science identity trajectories of four students who, in the fourth grade, all "performed themselves as scientifically competent and engaged learners who recognized themselves and got recognized by others as scientific," but who, over the next two years, in classrooms which were "dominated by low-level, minimally demanding tasks," began to "disengage from and/or resist school science" (Carlone, Kimmel, Lowder, Rockford, & Scott, 2011). In short, we do not know almost anything about how (or even whether) science identities turn into science trajectories. For research in science identities to meet my second test of consequential validity, tools are needed to allow for the study not only of identities but also of trajectories.

Later on in this chapter, I will sketch out what these tools might look like and give examples of the kinds of insights they can yield, but first I want to finish off this section on tests of consequential validity by looking at the third test: does an identity research study help better understand power?

Understanding Power

This third test of consequential validity needs a theoretical framework to support the ways in which research into science identity can give us insight into power. To develop that framework, I want to return to the data I presented above, on science test scores and participation rates. If we assume that these differences do not result from inherent differences in human biology, we must ask ourselves: In that case, what caused them? Under-representation in science is sometimes framed as a deficit in the members of the under-represented groups. This is the logic behind programs designed to stimulate interest in science. The assumption is that the reason certain groups are under-represented is something about those groups (they lack sufficient interest), not about science.[5] The solution, therefore, is to fix the groups (make them interested).

But let us imagine a situation where there are plenty of people from these underrepresented groups who have an attraction to scientific thinking, to the deep study of nature. In that case, how do we understand their under-representation? To explore this question, I would like to borrow a metaphor from Camara Phyllis Jones, whose work is in public health (Jones, 2000). Jones asks us to imagine a gardener with two identical packets of seeds. One packet is sown in rich potting soil; the other is sown into soil that is poor and rocky. We can imagine that the seeds in the richer soil will be more likely to germinate, and even the weaker seeds have a chance of producing flowers of middling height. The strongest seeds can produce tall, strong, vital flowers. In the poor soil, however, even the strongest seeds may only produce middling-height flowers *even though the seeds were identical to start with*.

Now imagine that the seeds were identical except that they produced flowers of different colors. The seeds sown into the rich soil produced red flowers; those in the rocky soil, pink flowers. Hasty observers might find it easy to conclude that the red flowers were inherently superior. Jones uses the rocky soil as a metaphor for institutionalized racism, and the metaphor of the seemingly-stronger red flowers as a metaphor for deficit-based explanations of the poorer educational, health, and economic status of members of stigmatized racial groups. Of institutional racism, she says that it

> manifests itself both in material conditions and in access to power. With regard to material conditions, examples include differential access to quality education, sound housing, gainful employment, appropriate medical facilities, and a clean environment. With regard to access to power, examples include differential access to information (including one's own history), resources (including wealth and organizational infrastructure), and voice

> (including voting rights, representation in government, and control of the media). (p. 1212)

Jones uses this metaphor to talk specifically about racism, but I would like to extend it to talk about all sorts of under-representation; in the case of science, the under-representation of white women as well.

Within science, the rocky soil for many people of color might include inequitable access to quality schooling. For all under-represented folks, the rocky soil would include the stunningly persistent and hard-to-eradicate image of scientists as white men in lab coats (Barman, 1996, 1999; McDuffie, 2001); and institutional and cultural features which are more well-aligned with white male norms and behaviors than with the values and behaviors commonly practiced by–and thus comfortable for–women and men of color. For women in science, Seymour and Hewitt (1997) argued that many of the institutional features of university science (large "weed-out" courses, little or no interaction between students and professors, hard grading) are congruent with male cultural norms and rites of passage but, to female students, seem pointlessly hostile. Whereas male students are able to read these forms as rites of passage that, if survived, will be followed by acceptance into the science community, female students find the same norms profoundly discouraging. Thus, "in treating male and female students alike, faculty are, in effect, treating women in ways that are understood by the men, but not by the women" (p. 261).[6]

Historically, a few individuals have managed to make it through this system, including famous examples like George Washington Carver and Marie Curie, and less famous examples like Roger Arliner Young, an African American woman zoologist who came to prominence in the 1920s (Manning, 1989). Many more make it through now. So let us look at another assumption. Let us assume that they made it through only not because they were exceptional individuals (though they undoubtedly were). Let us assume that, talented and hardworking though they were, they were no more so than many others who did not make it through; the difference was not in their science ability but in their luck and their ability to manage the institutional practices that made science inhospitable to them, to thrive in the rocky soil. They somehow managed to perform identities that let them persist. What–the question then becomes–did these identities look like?

And with this question, at last, we return to how the study of science identity can shed light on power. Studying identity involves studying the things people use, do and say in a setting; and which of those combinations of artifact, action and speech are celebrated in a setting, and which are marginalized. It involves looking at how people in a setting position themselves (their bids for recognition), and how they are positioned by others (whether those bids are accepted; whether other unwanted identities are ascribed to them). The "soil" in science, the institutional context, is particularly rocky for certain groups of people: the students of color and women whose forbears were more likely to be the subjects of scientific study than the scientists; the people whose socioeconomic backgrounds have denied them access to the best early science instruction. Studying what happens to these people

(the ones who make it in science nonetheless and also the ones who do not) has the potential to yield up a whole treasury of insights about how power operates.

If this is our goal–studying science identity as a way to understand power–we return to the need to think about not only in-the-moment identity performances but also how those performances, strung together over time and over many settings, condense into patterns, habits, trajectories. As Heidi Carlone and I put it (2007),

> Although we recognize that identities get formed in practice (Holland, Lachiotte, Skinner, & Cain, 1998; Lave & Wenger, 1991; Rahm, 2007), we also take into consideration that, over time, people's performance, participation patterns, and expectations become patterned and habitual. Through their years of science education, students learn to participate in similar practices in similar ways and often get recognized (or not) in similar ways. We see science identity as fragile (contingent, situationally emergent) and, if habitually accessed, performed, and recognized, as stable, carried across time and context (Elmesky & Seiler, 2007; Roth, 2006). (p. 1192)

To understand how power flows, we need to study the performance of identity in the moment; how an identity enacted in the moment can turn that moment into a "moment of agency," a space and time where an individual can take action to better their life, attain their goals. We need to search through all the moments of identity performance, to find the places where there is room for agency. Basu, Calabrese-Barton, Clairmont, and Locke (2009) define agency as both taking action "with the aim of creating, impacting and/or transforming themselves and/or the conditions of their lives" and, more politically, as "a process of understanding the effects of oppression and leveraging resources to act against it" (p. 355). However, we need to study this not just as an end in and of itself but as a way to get at how many moments of agency string together (or do not) into what could be called a trajectory of agency.

Power accrues over long time scales; it may be endlessly recreated, but not with random power distributions in each recreation. Over and over, even as power is recreated in the moment, it is recreated in the same way. So using identity as a tool for furthering social justice demands the study of these patterns; demands that we figure out how something that is endlessly recreated nonetheless mostly maintains the status quo. We need to study both momentary performance and also habitual patterns; snapshots and time-lapse photos; and, especially, we need to study how the one turns into the other.

REMAINING QUESTIONS AND METHODOLOGICAL DEMANDS

For researchers who are persuaded by the tests of consequential validity I have laid out above, we are in good shape with the first test. Studies of identity performance can offer us considerable insights about making science literacy available to all kinds of students. When the settings under study include adults from under-represented groups, these studies can even yield insights about how to support individuals who have persisted in science. What snapshot identity studies cannot

do, however, is tell us how that persistence takes place over time. Snapshot identity studies can let us understand how power is distributed moment-by-moment but not how those distributions fall into longer-term patterns.

So what kinds of research could preserve the power of identity research to let us look deeply into a setting to understand how the individuals in it are using speech, objects and actions to shape their relationship to science and the relationship of others in the setting, while strengthening the consequential validity of this line of research? I can see two ways to go about this: 1) Following groups of students across time to see how their science identities form, develop, and persist (or atrophy), and 2) locating individuals who have maintained consistent science identities over time and interviewing them retrospectively.

The former approach has great strength and richness; I imagine, for instance, the kinds of insights we could gain from locating a group of eager participants in an urban after-school science program for elementary grades, and following them for ten years. I believe that this approach would let us study which components of science identities are resilient across time, which are more vulnerable to context, and what teaching approaches help individuals enhance their resiliency and protect their vulnerability. There is also so much to be learned about science identity from those who enter and then leave science contexts. However, there are significant drawbacks to this approach. First, it is costly and takes a long time to gather this kind of data. Second, there is the real risk that none of the children will actually persist in science.

The latter approach, working backwards from persisting adults, has its own strengths and drawbacks. It is a great deal quicker and easier to locate persisting adults and interview them than to follow a group of science-identified children, hoping that at least some of them will persist to a science-based career. It also allows us to draw on the insights of the individuals themselves; they have lived through the experiences, they can tell us outright what helped them and what hindered them. However, this latter approach has two significant drawbacks. First, we cannot learn from it about the individuals who started out with promise in science but left; second, our only data source is the individuals' own memories; we cannot see for ourselves the kinds of identities they were manifesting in various settings, we can only attempt to reconstruct those identities from the stories they choose to tell us.

So what specific data-gathering techniques would be appropriate for longitudinal studies of promising cohorts of children, retrospective accounts from those who have persisted with science, or hybrids of these approaches? I propose the following:

- Accounts of the types of identity performances which are celebrated in the science settings frequented by participants (the actions, speech and artifacts employed), the kinds of people who can most easily enact these identities, and the way race, class, gender and other elements shape these identities;
- Trajectories of these in-the-moment performances over time–the sorts of relationship to science which certain kinds of performances often end up linked to;

- Individuals' retrospective accounts of the performance of identity–what they report they did, said and used–analyzed through the perspective of their current membership (or not) in science settings;
- Trajectories of these retrospective accounts over time.

A BRIEF EXAMPLE OF AN ACCIDENTAL IDENTITY TRAJECTORY STUDY

Since 1997, I have been following a group of women of color who were, at the outset of the research, undergraduate science majors at a predominantly White university. I did not set out to follow them longitudinally; I just set out to write my dissertation. But over the years I have remained in contact with many of them, and have used our ongoing ties to collect retrospective accounts of their pre-college science experiences and follow their post-college careers. I have, in short, stumbled into a kind of hybrid of the two types of research studies I called for above: a longitudinal study of successful science persisters which also includes retrospective accounts of participants' science identity before the beginning of the study. I will use the remainder of this chapter to present some of the findings that emerged from this study, to show the kinds of insights that can come from building snapshots of identity into time-lapse trajectories of identity.

The data was collected from 1997 to 2010. Data included records of in-the-moment identity performance, collected by attending undergraduate science classes, homework sessions and social events with participants; participants' concurrent and retrospective accounts of their identity performances and the meaning they made of those performances, collected via numerous formal and informal interviews over the years; and assembling trajectories of these performances, both by eliciting retrospective accounts from some participants ("tell me your life story as it relates to science") and by analyzing the data to assemble trajectories, which were then checked with participants and refined accordingly.

Data was analyzed by coding all transcripts and field notes into relevant domains and organizing those domains thematically (Spradley, 1979, 1980), using the domains to generate assertions (Erickson, 1986), returning to the data to generate examples which confirmed or challenged those assertions, and finally returning the assertions which withstood this re-examination to participants. This final member-checking consisted of presenting key findings to focus groups of participants and incorporating their refinements, and of asking various participants to read over many drafts of conference proposals and papers, again incorporating their feedback.

Through this process, I have established the kinds of identities that my participants formed in earlier educational settings, including k-12 science classes, science enrichment programs (which several participants reported as central to their later success), college, graduate school and professional settings. Not all the common threads among them were related to the science itself. They all manifested strong science identities in a variety of settings and stages of their lives, including strong affinities to science (my favorite quote: "there's nothing as interesting as a

cell"), deep science knowledge and capable scientific skills (manifested through good grades, invitations to work in research labs, graduate school acceptance, fellowship awards, publications, and advancement in science-based careers). But there were other common threads as well, threads that have potential both to better understand science persistence and to better understand power itself; I present several of these below.

Insights from Studying Identity Trajectories

First, many of the participants, in the face of discouraging conditions in their science classes or overt suggestions that they leave science, relied on their vision of themselves being able to use science in the service of others (Carlone & Johnson, 2007; Johnson, 2006; Johnson, et al., 2009). They pictured their future selves, called on their future identities, to help them tolerate the discomfort of their current settings. One, an American Indian biology major (now a doctor), told me during her junior year in college that "I do not really have a feel for the science department. But working with other people, and being active with other communities of color, you learn about their struggles and this or that, and so when you apply both of them together–biology and working with people–I can see that medicine is one way to connect them all." An African American senior (also a doctor now) said "I do not really care for chemistry too much, do not care for physics, but biology, for some reason, I just really have always liked it…I think it is just a way for me to make a place in the world where I feel like I'm making a difference for other people, which is important for me."

Second, at least some of them had the ability to read a situation and quickly throw together an identity performance which would get them recognized as belonging (Johnson, et al., 2011), a strategy they developed over time, usually after first using it unsuccessfully. In this quote, a Latina (now a Ph.D. candidate) recounts an incident from her sophomore year in college, in which she was trying to position herself as an aspiring pre-med student but was suddenly put on the spot as a person of color. At the time, she was not able to throw together an identity performance that could salvage the situation: "And they started talking about something else. And I just was sitting there like, uh, do I respond to that and if I was, what do I say, and it is definitely past the point of being witty to even respond because now they're talking about something else." Her friend, an African American woman (now working in public health), reflected on this story by talking about what she has learned since that time: "I know to 'tuck' my hair[7], like I know to up my [western] flat accent, and throw in words like 'unequivocally' when I need to…But that, that is really the bitch of it. That we all know when to 'man up' 'straighten up'…or 'whiten up' as needed…"

Another insight which would have been impossible without the identity trajectory approach: The same women who eventually became adept at producing acceptable identity performances also, in other times in their lives, manifested unusually strong political involvement. One led a student walk-out during high school, demanding more Latino content in the curriculum; another self-identifies as

a radical feminist; a third has chosen to work in the Indian Health Service because her motivation to do science is impossible to untangle from her determination to serve people like her own family. As she told me during an interview, "I do not know why I would go with any other health systems, because that is who I am. It finally hit me, it would seem so obvious, 'What is your family? Where does you family go? Where does your uncle go to receive healthcare?' They go to IHS. 'Where do your aunts go?' They all go to IHS. So, you know, I have to stick with it, I have to stick with IHS."

My colleagues and I (Johnson, et al., 2011) made the argument that this sensitivity to issues of power and justice actually prepared these women to become nimble at sensing the kinds of performances they needed to enact in rapidly-changing contexts in science; being sensitive to power seemingly helped them develop agency in the face of power. The same political savvy also let them identify, and, thus, avoid, the contexts in which shaking those negative ascribed identities would be extremely difficult. Using a definition of identity that focuses both on in-the-moment performance and on the way that momentary performances gradually evolve into long-term trajectories let us find this tantalizing clue.

And Back to Consequential Validity

Thus, I would argue that my own research has begun to meet the second and third tests of consequential validity that I laid out above. By arranging participants' identity snapshots from particular places and times into identity trajectories across time and space, I was able to identify some strategies used by science persisters. I was also, I think, able to think more abstractly about power and agency. And this was without purposely setting out to study identity trajectories. I would very much like to see other researchers take up this call to try to use our identity snapshots to piece together identity trajectories; I have the sense that this process can offer compelling insights not only into science education but, more broadly, into social justice.

NOTES

[1] This is easier to understand when you think about test score uses, which have poor consequential validity. An example that is particularly relevant as I write this is using student test scores to evaluate teachers. Value-added methods of calculating teacher quality are currently very unstable. In one study, among the teachers who scored in the top 20% one year, fewer than a third were in that group the next; another third, moreover, had fallen to the bottom 40% (EPI, 2010). Thus, this approach to evaluating teachers has poor consequential validity; the consequence of using it might be to promote or dismiss teachers haphazardly.

[2] Racial/ethnic identifiers are those used by the College Board.

[3] The NSF college graduation data included a variable called "science," but which includes students who majored in the social sciences and psychology. Because so many women major in these fields, this variable was not a useful measure of the dynamics of interest to us. Thus, I used raw data to calculate my own measure of the number of students who graduated with majors in agricultural, biological, computer, earth, atmospheric and ocean, mathematical, and physical sciences.

[4] For this data, I again had to calculate my own percents because the NSF data included psychologists and social scientists. This time, I tallied the counts of biological/life, mathematical, and physical scientists.

[5] I want to make a distinction here between programs designed to give people *opportunities* to do science and programs designed to stimulate *interest* in science.

[6] Jones lays out two other levels of racism and inequity besides the institutional level; there is also personally mediated racism and internalized racism. By personally mediated racism, she means what people frequently mean when they talk about racism in general: Prejudiced assumptions and discriminatory actions on the part of individuals. Internalized racism is "acceptance by members of the stigmatized races of negative messages about their own abilities and intrinsic worth" (p. 1213). Note that any remedies with the goal of stimulating or supporting interest on the part of underrepresented folks only address the internalized level of obstacles; the belief that women or people of color cannot do science. But as Jones points out, changing this belief in the minds of particular students will do nothing at all to change the inhospitable conditions they face; the rocky soil. Even remedies designed to lessen personally mediated racism (for instance, sensitivity training for science professors) have only very limited efficacy. The only truly just remedies work at the institutional level. However, confronting these conditions head-on–ensuring that all seeds can grow in the same fertile soil–is the work of generations, and even then may fail. I think about at the heroic efforts for educational equity of African Americans. The first court case fighting legal segregation, Roberts v. Boston, took place in 1850, more than 100 years before the Brown decision; and today, over 50 years after Brown, Black children on average still attend schools with less experienced teachers, fewer resources, and less funding than White students; we are not even at the 1896 standard established in Plessy v. Ferguson—separate but equal; we still have separate and unequal schooling for most Black and Latino schoolchildren in America. Fertilizing the soil is a long, slow process.

[7] She is referring to another story she told about an incident from high school: "I remember in the interview wearing my hair down and gelled up so it wasn't too poofy. But at some point, I actually tucked my hair behind my ears (well made the motion, there was no tucking of my hair behind any ears). But in a gesture that I must have seen white girls in my school do for years."

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13. DEVELOPING CRITICAL CONVERSATIONS ABOUT IDENTITY RESEARCH IN SCIENCE EDUCATION

The chapters in this book offer a range of points of view concerning identity and its relationship to participation in science education. In the studies presented, identity is foregrounded to show various ways in which learners, teachers, students, children, and adults take on, and are positioned with, different ways of being with consequences for achievement, emotional well-being, career paths, and status within groups. I take a sociocultural point of view when reading these chapters. Across the studies, I view identity as constructed as members of a group affiliate over time and build ways of talking, acting, and being that define collective membership (Gee, 2001; Kelly & Green, 1998). Within such social groups, individuals take actions to position themselves and define for themselves and others how they can be, and are, interpreted as members in the group. The participants in the examples provided have multiple affiliations, with associated ways of being, which may contrast with the ways of being in the local social group in the science education setting in question, leading to misunderstanding or conflict (Kelly & Green, 1998). Identity work includes how members of groups choose to participate, but also how they are positioned by actions of others, which impose constraints on potential identity development. Thus, in each case, an analysis of identity needs to examine not only the actions in the moment-to-moment discursive events, but also how such actions are part of interactional sequences, and how such sequences are made possible, but also constrained by the speech genres relevant to the social group (Kelly, 2008). From a sociocultural point of view, learning to be a member entails participating in social groups by building repertoires of discourse and ways of being that are viewed as making sense within the relevant group. From this perspective, identity can be seen as relational and social, tied to how people are positioned by others, and also how they take up identities, establish agency, and build repertoires of participation.

The range of participants, educational settings, and analytic foci of the chapters in this book provide an opportunity to consider a number of questions pertaining to identity. What are the conceptions of identity inscribed in the theoretical perspective of the authors? How does the focus on identity make visible relevant educational issues? What is at stake regarding identity within and across the various social groups? I then pose some questions across the cases in an effort to advance the field regarding issues of identity, discourse, and affiliation. These

M. Varelas (Ed.), Identity Construction and Science Education Research: Learning, Teaching, and Being in Multiple Contexts, 189–196.

questions include: What research directions emerge out of these studies regarding identity, learning, teaching, and so forth? How does identity research make visible salient educational issues? To address the questions, I propose a series of critical conversations that examine the scholarship around identity, commitments of the field to principles for quality research, and ways that identity research connects with other research areas in science education.

CASE STUDIES OF IDENTITY

In this section of my commentary I focus on the five studies in *Part 2: Teachers and Practitioners of Science* of this book. The chapter by Angela Johnson considers identity in the broader context of science education for social justice. The chapter poses self-reflective questions about research in science education, and then focuses on the author's own research regarding identity. The chapter builds on the social science construct of consequential validity and uses tests to examine how research can be construed to adhere to such validity. After identifying the various forms of inequality in US science education, the author considers how a focus on identity can help improve access to scientific literacy, persistence in science, and understanding of how power is used in science education settings. The theoretical perspective of the chapter by Johnson considers identity across timescales from snapshots to time-lapsed events to examine science identity trajectories for participants as they progress through various experiences in science. This perspective includes the short-term interactional accomplishment of identity, but also how various experiences build relationships with science as participants enter into professional careers. This focus on identity across time, and centered on affiliation and participation, places importance on the ways participants' identities in science form, persist, and atrophy. This perspective suggests an examination of how identity progresses as participation in science changes over time and how short-time identity development connects to trajectories over time: "What we need is a way to connect the two: the short-term and medium-term identities manifested in science learning settings and the long-term trajectories of individuals who have been able to enter into science-based professions" (Johnson, p. X). In the studies cited in the chapter, Johnson shows how her focus identifies how people's own views of themselves, and their envisioned future identities, help them persist in science against the constraints they faced. Interestingly, this self-awareness also led some of the participants to learn to perform in such a way as to be recognized as members of the local science culture in their setting. Through this focus on identity trajectory, Johnson was able to identify how learning to perform in such social situations led to increased political involvement. For Johnson, a key aspect at stake for science education is access to science. The chapter points out that students may develop some affiliation with science, and learn how to perform science identities in educational contexts, but still may choose to leave the field as a professional option.

The chapter by Felicia Moore Mensah considers positional identity. This view of identity considers the importance of proximal positional factors of race, class,

and gender in construction of preservice teachers' identity. The theoretical perspective put forth by Mensah considers not only how identity is relational, but also, through interaction, how power relationships make visible sociocultural, sociohistorical, and sociopolitical dimensions of identity. As the focus is on science teacher identities, Mensah considers the race, ethnicity, economic status, gender, religion, and age of the teachers in the study and how "their views of self influence the ways in which they talk about their teaching and science teacher identities" (p. X). Mensah created case studies through conversational interviews and a card sort interview technique to make visible the ways proximal social markers contribute to the preservice teachers' positional identities. Across the cases, the social markers of race, religion, gender, age, and ethnicity differentially contribute to the specific cases developed. In one case, a preservice teacher, Monroe, made choices for his career path purposefully to avoid his view of the "smart Asian American stereotype." In this case, decisions about becoming a teacher, and how this preservice teacher sees himself, relate to his interpretation of cultural perceptions. Across the three cases presented, what is at stake is preservice science teachers' (PST) views of themselves, and through such perceptions, how they view their roles as teacher in relation to students. The importance of considering identity in teacher education made clear, Mensah argues that a focus on identity in teacher education "can foster the development of relationships with science and students and [help] PSTs to critique their positioning" (p. X). The chapter concludes by noting the potential of considering the multiple social identities in science teacher education.

The chapter by Maria Rivera Maulucci takes a unique look at identity. While each of the chapters in this section of the book place social justice as a normative goal for education and educational research, this chapter considers the role of identity and emotion for teachers interested in developing social justice pedagogies. Maulucci defines identity and its relationship to emotions as follows: "I envision identity as relational to our unique personal and cultural histories; our goals, interests, desires and physiological states; our roles, and the social context. In addition, our emotions may be seen as one of the central mediators of our relational identities, or ways of being in the world" (p. X). This is a broad view of identity. To examine identity and emotions, the study drew from a number of research interviews and applied a critical narrative inquiry framework for analysis. This analysis makes visible the anxieties and strains faced by teachers trying to enact social justice pedagogies. Each of the three teachers studied faced different issues in their teaching, which produced different emotional responses. In each case, the teachers found ways to work through their emotions, as their identities grew and changed over time. The study, thus, made visible the constraints facing teachers derived from the difficult emotional situations they were experiencing. The chapter makes the case that emotions are important factors to consider in teachers' professional lives. In the seemingly rational world of teacher education, emotion is often forgotten. As attention is being paid to identity development in teacher education, the role of emotions and how they need to be considered becomes salient. Teachers' identities are complex, ever changing, and difficult to

assess and understand. This chapter provides a caution: approaches to the study of identity, particularly as connected to pedagogical change, need to take into consideration the emotions of teachers.

The chapter by Kenneth Tobin and Reynaldo Llena views identity as dynamic and mediated by an individual|collective dialectic. By setting the unit of analysis as social interaction, the authors unpack identity by asking: "how does a person consider him/herself in relation to those with whom she/he interacts?" This case study considers the myriad of ways identity is constructed through a lifetime of experiences for one science teacher, the co-author, Reynaldo. The chapter shows how across different aspects of this life, growing up in the Philippines, reconciling religion and faith healing with science, and taking on the role of science teacher dedicated to student success contribute to an ever-changing conception of identity. The time as a science teacher afforded Reynaldo the opportunity to learn with and from his students through co-generative dialogues (cogen). Interestingly, just as Reynaldo shows agency in choices that he made about his career, his students take on cogen to both improve their education experiences, but also challenge his authority in the classroom, thus, posing a challenge to his constructed identity. Through struggles with educational authorities, Reynaldo finds that teaching is too stressful, leading to physical and psychological illness. While his identity is connected to being a science teacher, he comes to realize that he needs to take on new and different challenges. Much like the chapter by Maulucci, emotions played a mediating role in the construction of identity.

The chapter by Allison Gonsalves and Gale Seiler examines the role of identity in graduate education. This chapter considers the ideological framing of physics as a discipline populated by super smart individuals, with little regard for the mundane details of everyday life. The study makes clear that stereotypical descriptions of physicists as "dispassionate, rational, objective, and overwhelmingly, White, geeky, and male" (p. X) serve notice to students entering the field. This ideological depiction of physicists serves to discourage many students, particularly women, from affiliating with the discipline. Alternatively, to get by as members, these students may need to learn to take on the pretense of the characteristics of the stereotype. The chapter considers Gee's figured worlds as a basis for how identity is inscribed in everyday practice. Students learn that competence is often judged by the extent to which a member learns to be "one of the guys." This image is linked to a number of practices that can arguably be tied to the actual work of physicists, such as commitment and technical, analytical, and academic competence. By considering the figured worlds of physicists in a particular institution, Gonsalves and Seiler demonstrate how forms of competence (relevant to scientific practice) are constructed along with images and ways of being associated with the stereotypical physicist. By looking at identity as participation in figured worlds, rather than (say) subject positions (often not available to women in physics), the chapter shows how one student, Ruby, is able to perform the stereotypical behaviors to be recognized as competent. This affords her access to a community of physicists; a community to which she ironically feels marginalized even when she is ostensibly participating. The chapter shows that

graduate education faces many of the same issues as other parts of the educational system for learning to be a member. While technical, analytic, and academic competences are seen as the defining abilities that open and limit access, a close examination evinces the ways in which gender ideology and cultural norms alienate potentially competent members of the group.

RESEARCH ISSUES EMERGING FROM CASES

The case studies in the five chapters in Part 2 of the book, along with the studies reported in Part 1, raise a number of research issues for the field of science education and the area of research on identity and education more broadly. First, the chapters make plain that identity is a complex construct, and in each moment of interaction, identity can both frame the interaction as well as be changed through the interaction. In this way, identity can be understood as constructed over time with durable features, while always subject to modification and change. The chapters, thus, speak to the importance of considering different timescales for the study of identity and discourse processes, from the micro-interactional, to the meso-level, to the ontogenetic, to the sociohistorical (Wortham, 2003). Second, identity is constructed in social contexts, with assumptions and cultural practices beyond those of the individual. In the cases presented, individuals are positioned and identities constructed in social situations where cultural practices afford certain opportunities, but also limit potential identity futures. Thus, individuals do not just slot into certain discourses that afford membership in a community. The processes are dialogical and dialectic, as individuals bring a history of experiences with aspirations and repertoires for speaking, acting, and being. Membership and affiliation are determined by actors within collectives, with affordances and constraints of the cultural milieu. Third, the actors in the case studies have agency. The authors of these chapters took care to emphasize the importance of recognizing the learner, teacher, scientist as human with agency and ways of being that can be respected, ignored, affirmed, and so forth. The emotional strain associated with cultural differences and alternative ways of being often led to alienation from a particular group or profession.

These issues raise a number of questions about future research on identity and science education. While a number of educational concerns have been identified, to foster on-going dialogue about educational matters I propose engagement in critical discourses. The chapters are question-posing and open areas for further development and consideration. By fostering critical discourse around identity we may be able to advance the field through mutual learning.

FOSTERING CRITICAL DISCOURSE FOR IDENTITY RESEARCH

Across the five chapters, the authors have raised a number of definitional, methodological, and functional issues. To further consider some research directions vis-à-vis identity and science education research emanating from this work, I draw from a framework for critical discourse (Kelly, 2006; Strike, 1995).

This framework builds on Discourse Ethics (Habermas, 1990) to consider how differences in points of view can be adjudicated through dialogue. I apply the framework in this case to research groups focused on identity in science education. This framework offers three types of critical discourse to consider discourse across differences.

The first is *critical discourse within group*. The purpose of these conversations is the developmental and definitional work regarding the creation, specification, and extension of a research group's central theories, assumptions, and key constructs (Kelly, 2006). Within group critical discourse provides a forum for development of a research area's core theories and commitments. In the within group conversations, we see the premium on the development of new ideas, metaphors, and redescriptions (Rorty, 1989). In these critical conversations, researchers create new vocabulary to make sense of our world. Identity research offers such new ways to redescribe social processes in science education. The current research base has identified a number of identities (e.g., science student identities, positional identity, teacher identity). Within group critical discourse can focus on how to refine and understand identity in its many forms, establishing some clarity and cohesiveness, if not consensus, on this central idea.

Critical discourse regarding public reason focuses on the development of epistemological commitments to assess the value of educational research within and across different research traditions (Kelly, 2006). We may think about this in terms of criteria used to judge research. Some likely reasons to value research may be insightfulness, theoretical salience, consistency with other knowledge, usefulness for practitioners, and so forth. We can examine identity research along these lines of thinking in at least two ways. First, we may consider the substantive contribution of the work on identity to the field of science education research. The chapter by Johnson makes the case for a consideration of consequential validity in science education research in general, and in research related to identity in particular. Part of the discourse around public reason concerns how the value of research should be judged. How do we as researchers value certain research? What are we looking for in the study of identity? The cases presented in the chapters evince the importance of identity as a way of understanding affiliation or alienation from science. Thus, identity is viewed as a construct that contributes to developing social justice in science education. A second way we may consider issues of public discourse concerns the epistemological commitments of the field regarding research methods. How is identity researched? What counts as valid and useful research in this area? While there is an emerging sense of the importance of identity in science education, particularly as related to studies of discourse, access, and equity, there are ambiguities about how to research identity across contexts and timescales, thus, offering the field opportunities to engage in critical discussions about the epistemology of social science research. Each of the chapters offers unique insight regarding identity by using a small number of illustrative cases. The chapters use interviews, card sorts, and cogenerative dialogues to identify how identity sheds light on issues of participation in, or alienation from, scientific and science teaching practices. Building on the case studies, the field

may consider how to establish evidence and creative persuasive arguments for how identity work can be integrated into science learning, teacher education, and professional labor.

Hermeneutical conversations across groups is a third critical discourse to consider (Kelly, 2006). The purpose of these conversations is to learn from differences across traditions, and consider the multiple audiences for our work. There are many ways in which research in science education from an identity point of view has similar goals to research using different theoretical traditions. We can consider at least three sorts of conversations about how research on identity ties into other traditions in the field. First, we may consider how research on identity can be informed by, and inform, the development of specific research methods for science education. For example, research on identity may invent research approaches relevant to other research areas. Second, we can consider how different theoretical traditions examine similar substantive issues around identity. There are many different views of identity and types of identity, as seen in the chapters in this book. There may be interesting differences in how identity is recognized, examined, and constructed in and through research from traditions in linguistics, psychology, anthropology, and so forth. Third, another hermeneutical conversation concerns how identity ties to other sorts of research. These chapters have pointed to the potential of research on identity to connect with research on classroom discourse, student learning, or teacher education. The chapters in this book show how there are legitimizing institutions with certain values that may not mesh well with students' and teachers' ways of being. Developing a research program addressing these problems may require examining how different approaches are mutually supportive and synergistic. I have suggested we consider engaging in a variety of critical discourses to advance the field in this area.

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