In this edited volume, science education scholars engage with the constructs of identity and identity construction of learners, teachers, and practitioners of science. Reports on empirical studies and commentaries serve to extend theoretical understandings related to identity and identity development vis-à-vis science education, link them to empirical evidence derived from a range of participants, educational settings, and analytic foci, examine methodological issues in identity studies, and project fruitful directions for research in this area. Using anthropological, sociological, and socio-cultural perspectives, chapter authors depict and discuss the complexity, messiness, but also potential of identity work in science education, and show how critical constructs—such as power, privilege, and dominant views; access and participation; positionality; agency-structure dialectic; and inequities—are integrally intertwined with identity construction and trajectories. Chapter authors examine issues of identity with participants ranging from first graders to pre-service and in-service teachers to physics doctoral students, to show ways in which identity work is a vital (albeit still underemphasized) dimension of learning and participating in science in, and out of, academic institutions. Moreover, the research presented 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, and linked with science achievement gaps. This book contributes to the growing scholarship that seeks to problematize various dominant views regarding, for example, what counts as science and scientific competence, who does science, and what resources can be fruitful for doing science.
Identity Construction and Science Education Research
Scope:

Bold Visions in Educational Research is international in scope and includes books from two areas: teaching and learning to teach and research methods in education. Each area contains multi-authored handbooks of approximately 200,000 words and monographs (authored and edited collections) of approximately 130,000 words. All books are scholarly, written to engage specified readers and catalyze changes in policies and practices. Defining characteristics of books in the series are their explicit uses of theory and associated methodologies to address important problems. We invite books from across a theoretical and methodological spectrum from scholars employing quantitative, statistical, experimental, ethnographic, semiotic, hermeneutic, historical, ethnomethodological, phenomenological, case studies, action, cultural studies, content analysis, rhetorical, deconstructive, critical, literary, aesthetic and other research methods.

Books on teaching and learning to teach focus on any of the curriculum areas (e.g., literacy, science, mathematics, social science), in and out of school settings, and points along the age continuum (pre K to adult). The purpose of books on research methods in education is not to present generalized and abstract procedures but to show how research is undertaken, highlighting the particulars that pertain to a study. Each book brings to the foreground those details that must be considered at every step on the way to doing a good study. The goal is not to show how generalizable methods are but to present rich descriptions to show how research is enacted. The books focus on methodology, within a context of substantive results so that methods, theory, and the processes leading to empirical analyses and outcomes are juxtaposed. In this way method is not reified, but is explored within well-described contexts and the emergent research outcomes. Three illustrative examples of books are those that allow proponents of particular perspectives to interact and debate, comprehensive handbooks where leading scholars explore particular genres of inquiry in detail, and introductory texts to particular educational research methods/issues of interest to novice researchers.
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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...
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 Coté 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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HEIDI B. CARLONE

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;
H. B. CARLONE

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

<table>
<thead>
<tr>
<th>Over-riding questions for observations:</th>
<th>Description and Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are students doing, saying, and producing? (Spradley, 1980)</td>
<td>Examine the ways students investigate scientific questions using empirical data and their prior knowledge. Examples: observation, data collection, problem solving, testing ideas.</td>
</tr>
<tr>
<td>What are all the regularly occurring investigative practices in the setting? Put differently: What are all the ways students engage in scientific investigation?</td>
<td></td>
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<tr>
<td>What are all the regularly occurring communicative practices in the setting? Put differently: What are all the ways students and teachers communicate?</td>
<td>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.</td>
</tr>
<tr>
<td>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?</td>
<td>Examine the ways that students and/or teachers infer, justify, evaluate, and legitimate scientific knowledge.</td>
</tr>
</tbody>
</table>

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.

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 represents 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?”

Figure 1. Examples of cards for the norms and values card sort interview protocol featuring a normative practice (left) and a value (right).
<table>
<thead>
<tr>
<th>Scientific practices*</th>
<th>Scientific Observation</th>
<th>Scientific Explanation</th>
<th>Review and Critique Scientific Knowledge</th>
<th>Justification</th>
<th>Legitimizing Science Ideas/Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celebrated/</td>
<td>What are celebrated</td>
<td>What are celebrated</td>
<td>What are celebrated and marginalized</td>
<td>What are</td>
<td>What are celebrated and marginalized</td>
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<td>and marginalized ways</td>
<td>and marginalized ways</td>
<td>ways to review/critique scientific</td>
<td>marginalized</td>
<td>ways to justify scientific</td>
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<td>to observe?</td>
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<tr>
<td>Actor(s) (central</td>
<td>Who observes?</td>
<td>Who develops scientific</td>
<td>Who reviews/critiques with what</td>
<td>Who justifies</td>
<td>Who legitimizes scientific</td>
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<td>and marginal)</td>
<td>Who doesn’t?</td>
<td>explanation? Who</td>
<td>arrangements of space and actors?</td>
<td>scientific</td>
<td>ideas?</td>
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<td>What are the times to</td>
<td>What are the times for justifying</td>
<td>What are the</td>
<td>What are the times for legitimizing</td>
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<td></td>
<td>observe? How often it</td>
<td>review and critique?</td>
<td>scientific knowledge? How often?</td>
<td>times</td>
<td>scientific ideas? How often?</td>
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<td>Space</td>
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<td>Where does knowledge get</td>
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<td>Talk (central</td>
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*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.

REFERENCES
METHODOLOGICAL CONSIDERATIONS


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