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Crafting a Future in Science: Tracing Middle School Girls' Identity Work Over Time and Space

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The underrepresentation of girls from nondominant backgrounds in the sciences and engineering continues despite recent gains in achievement. This longitudinal ethnographic study traces the identity work that girls from nondominant backgrounds do as they engage in science-related activities across school, club, and home during the middle school years. Building a conceptual argument for identity trajectories, the authors discuss the ongoing, cumulative, and contentious nature of identity work and the mechanisms that foster critical shifts in trajectories. The authors argue that the girls view possible future selves in science when their identity work is recognized, supported, and leveraged toward expanded opportunities for engagement in science. This process yields layered meanings of (possible) selves and of science and reconfigures meaningful participation in science.

KEYWORDS: equity, identity trajectories, gender, science education, sociocultural

The construct of identity has gained traction in the past decade as a useful lens for understanding student learning in science. Studies have focused primarily on how the process of becoming within a community of practice, such as the science learning community, is reflective of one's developing knowledge and practice within that community and how one is recognized by others for developing expertise (e.g., Brickhouse & Potter, 2001; Carlone,

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Haun-Frank, & Webb, 2011). However, identity studies are inherently complex. Who one is and who one desires to be at any given moment is always under negotiation and is contingent upon the resources one has access to and the social, cultural, and historical context in which one seeks to author oneself with and against the expectations of others (Holland, Lachicotte, Skinner, & Cain, 2001; Wortham, 2006). Because identities are always in the making and are always socially negotiated, they are impossible to isolate or to name, raising questions about how to study them.

In our work, we find it productive to focus on *identity work* rather than identities themselves. By identity work we refer to the actions that individuals take and the relationships they form (and the resources they leverage to do so) at any given moment and as constrained by the historically, culturally, and socially legitimized norms, rules, and expectations that operate within the spaces in which such work takes place. Individuals author possible identities through identity work over time both with and against the norms of the worlds they inhabit. As we later describe, there is always dialectical tension between the work that individuals do and how that work is taken up by others over time and space. In particular, we are concerned with how girls

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from nondominant backgrounds engage in identity work over the course of middle school—and across the spaces of school, afterschool science, and home—and what this tells us about their ongoing underrepresentation in the sciences and engineering.

Evidence increasingly shows that while White girls have nearly closed the science achievement gap with White boys, girls from other ethnic groups have not, and girls from all groups still opt out of science-related trajectories at far higher rates, especially in the physical sciences (National Academies, 2007; National Center for Education Statistics [NCES], 2007, 2011). What do girls do to author themselves into or out of science, in spite of—or because of—their grades?

In our work we are particularly interested in how girls from nondominant backgrounds author themselves in science over the course of their middle school years. Research indicates that the middle school years continue to be a crucial time when science and engineering interests and participation drop precipitously even when grades remain high (Hill, Corbett, & St. Rose, 2011). In a longitudinal study with Swedish youth, Lindahl (2007) found that girls' career aspirations were largely formed by age 13 and that engaging students in science beyond this point became progressively more difficult. Studies such as these indicate the importance of taking seriously career aspirations articulated by youth before they enter high school. It is therefore crucial to understand the formative experiences of youth and their career aspirations during the middle school years and to elucidate how to support their aspirations and interest in science, particularly those of girls (Archer et al., 2010).

Take the case of Diane, an African American girl from a small Midwestern city, who is one of the focal cases of this article. Diane consistently told us that she liked science because "science helps me to learn new things." She took her time completing her science assignments, often not finishing them during the allotted class time and sometimes turning them in late because she cared more about "figuring things out" than "getting things done on time." This approach contrasted with other girls in her class who were known as "really smart" and "class leaders" by their peers and teacher because they finished their work efficiently, often with the highest grades. During a seventh-grade lesson on invasive species where students had to create a poster depicting invasive species in Lake Michigan, Diane was the last student to complete the assignment and did not have the same free time at the end of the period as her friends. Her teacher pointed her out to us, stating that she usually needed "extra time" to get her work done. When we asked Diane what she learned in the assignment, she explained in depth the different invasive species, the role they played in changing the lake ecology, and how they got there. This stood in contrast to the "top student," who turned in her assignment first with all correct answers but answered our same question with a generic "I don't know, it was about

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invasive species." Even when pushed to say something about the invasive species, she replied, "I really don't remember." Despite what appeared to be a deep engagement in science, Diane was not recognized by her peers or teacher as a strong science student. Diane also indicated to us that she "couldn't care less" about her grades in science class because she was "not good at science." Even when the teacher offered extra credit opportunities for students to bring up their grades, Diane, who was one point away from an A-, opted to take the B+, telling us that, "I got As and Bs. I don't need all As."

Diane, like all young women, engages in ongoing identity work in the ways in which she positions herself in the moment as well as in the career pathways she chooses to work toward. Her identity work is also shaped by how others recognize and respond to the ways in which she represents herself and the actions she takes. As Diane's identity work occurs over time and space, it produces "traces of selves in science" (i.e., perceived meaning of selves to oneself and to others), which carry influence on future identity work.

For example, when Diane became known as a girl who did not care about grades and was slow to complete assignments, her peers and teachers built expectations of her that led to comments from her science teacher like "Diane needs extra help" and "She doesn't have the support at home," even though Diane did not think about herself that way in the seventh grade. These comments were only compounded by the historical narratives surrounding what it means for Diane to grow up lower income, in a one-parent household, as an African American girl, and in a small city marked by racial strife. The ongoing co-production of such identity work can powerfully facilitate and constrain access to possible science futures.

The questions that guide our study, therefore, are: (1) What kinds of identity work do girls from nondominant backgrounds engage in across the middle school years, and how is this work salient to potential futures in science? (2) How is the identity work in science of the girls shaped by their participation in school, home, and informal learning opportunities, like science club? (3) What shifts in the identity trajectories of these girls occur, and why?

These questions are important because little has been reported about the ongoing and interactive nature of the identity work that girls from nondominant backgrounds take on as they move through key spaces that make up life in the middle grades, school, home, and informal learning spaces and how this work is informed by race, class, and gender. Even less is known about the traces such identity work leaves and how these traces become salient in girls' future efforts to figure themselves in science. We are particularly interested in the *shifts* in the kinds of identity work that girls do—and how these shifts are recognized by others—because of the insights it may offer for designing learning environments supportive of girls' identity work.

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Conceptual Framework

Science Learning and Identity Work

Our study is primarily grounded in social practice theory and in feminist writings on intersectionality. From a social practice theory perspective, identities reflect one's ongoing social existence in the world. As individuals move through the world—through time and space, such as through middle school science—they are exposed to, positioned by, and react to a range of people as well as institutional and cultural structures and forces (Holland et al., 2001). Quite different from psychological studies that situate identity as a personal attribute, identities from this framework can be thought of as the ways in which people figure themselves and are figured by others as they "adapt to author themselves *in the moment* [emphasis added]" (Holland & Lave, 2009, p. 4). In other words, who one is, in the past, present, and possible futures, is informed by the encounters one has as one "address[es] and respond[s] to others while enacting cultural activities under conditions of political-economic and cultural-historical conjuncture" (Holland & Love, 2009, p. 3). As individuals join new communities of practice, they call upon salient practices and ways of being that are learned from other places, creating new hybrid practices that can position one as either central or marginal to their new community. Such acts of identity work are complex, for how one is recognized within new communities is an artifact of the power dynamics that operate there (Nasir, 2011) and that reflect the cultural norms of "local practice" and "historically institutionalized struggles" (Eisenhart & Finkel, 1998; Holland et al., 2001).

Identity is a powerful construct for understanding student learning because identities are constructed through practice—practice that requires knowledge, skills, and ways of thinking that characterize the discipline in which one is engaging. Science learning involves mastering systems of activities that involve social and cultural practices of science. Identifying oneself as an agent in the system (e.g., science classroom, science club) and having others identifying a person as an agent in the system is a part of mastering that system (Holland et al., 2001).

As indicated earlier, we use the phrase *identity work* to capture the idea that authoring oneself in science or in any domain involves an ongoing effort and positions the author with agency (Calabrese Barton & Tan, 2010). It is through the actions people take and the relationships they form that they position themselves as particular kinds of people over time and space. The reception, or recognition, of these positionings by the community highlights the dialectical nature of identity work. Because identity work happens within and against local norms and expectations and as a part of longer standing sociocultural and historical narratives, its outcomes are always uncertain and gain new meaning as they get traced in time. Using the

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example of middle school science class, as students move through seventh- or eighth-grade science, they encounter and become a part of powerful narratives, traditions, and histories that demarcate what it means to be a particular kind of person in science class. There are broader disciplinary narratives around what it means to be scientific, normative education narratives around what it means to be a good student, and cultural narratives around what it means to be a girl, a boy, an African American, an English Language learner, and so on. These broader narratives play out through the relationships and activities that students engage in at any given moment. The practices of the science classroom or the peer culture as informed by dominant norms and routines position youth in particular ways and they react to those positionings. It is this ongoing effort to continuously refigure oneself that is central to the *work* of identity. We say that such work will always have uncertain outcomes because it sits in tension with how others recognize that work. It also brings together "two forms of history"—the personal and the institutional—and as Holland and Lave (2009) argue, what emerges is a sort of "local contentious practice" grounded in "cultural-historical conjuncture" (p. 13). This latter point helps illustrate why the identity work of what might be on the surface two very similar individuals might ultimately take on quite different significance.

For girls in science, especially girls from nondominant groups, the institutional histories, or the norms and expectations for becoming in science, present particular challenges. Here we draw upon the feminist idea of intersectionality. Intersectionality is an idea that emerged in the 1980s from Third World feminists who argued that women's experiences are multiple, layered, and intersecting and that gender should always be viewed as dynamic and heterogeneous (cf. Crenshaw, 1989). This idea recognizes the ways in which girls' identity work takes place in figured worlds that bear particular structures of power, privilege, and oppression. Collins (2000a, 2000b) points out that "as opposed to examining gender, sexuality, race, class, and nation as separate systems of oppression, the construct of intersectionality references how these systems mutually construct one another" (Collins, as cited in Johnson, Brown, Carlone, & Cuevas, 2011, p. 343). Girls' experiences (and thus identity work) take place in what Collins (2000a) calls a "matrix of oppression," the structure that operates with race, class, gender, and other forms of oppression. The worlds of science that constitute the backdrop of girls' identity work are laden with their own norms, rules, and expectations that foster certain power structures, while at the same time schooling and society also have their own as well. Normative discourses and practices (of those in power—in science/Western society—mainly White, male, and middle class) position girls in real and symbolic hierarchies. We attend to the notion of intersectionality because it helps us to see and to interrogate the tacit structures of hierarchies in the worlds of school and of science

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(Johnson et al., 2011), both real and symbolic. It also helps us to work against essentializing girls' experiences in and/or with science.

Recognizing Identity Work in the Moment

Recognizing the kinds of identity work that girls do over time requires careful attention to (a) the system of activities in figured worlds where identity work takes place, including the roles girls play in these worlds while engaging in activities and the resources and strategies of action that they employ upon participation, and (b) the identity artifacts that reflect the outcomes of identity work over time, including both material and semiotic ones. We describe each in the following as we incorporate attention to issues of power and oppression.

Figured Worlds

We draw on the notion of "figured worlds" (Holland et al., 2001) to explain how identities are figured locally in time and place through dialogical negotiation within cultural contexts. Figured worlds are socially and historically where "people come to conceptually (cognitively) and materially/procedurally produce (perform) new self-understandings (identities)" (Urrieta, 2007, p. 108). Figured worlds can be structured simultaneously at the macro, meso, and micro levels. For example, science class can be viewed as a complex web of figured worlds, including the world of whole class activity with historical and cultural norms for participation and good studenting and the world of small group interactions as peers move in and out of different associations due to classroom tasks and social activity (Calabrese Barton, Tan, & Rivet, 2008). Within figured worlds, identity is made evident through what individuals say and do, how a student and their work is *recognized* and by whom, by the *resources* they access and activate to do so, and by how they *position* themselves in relation to others and to the object of the activity while taking particular *roles* (i.e., the science lab). Figured worlds are also governed by specific discourses (e.g., ways of knowing, doing, talking, being) that serve to delineate figured world–specific membership (Gutierrez, Baquedano-Lopez, & Tejeda, 1999). Girls author identities while traversing social spaces as responses to the structure of activities in figured worlds. Identities are made salient through the ways in which girls leverage resources, take on roles as a member of the community, and position themselves in the community and in how they are positioned and recognized by others.

Figured worlds help us to see the dynamic and oftentimes intentional nature of identity work. People are always involved in the process of authoring and reauthoring through participation in and resistance to the practices that make up each figured world. As Urrieta (2007) describes, "Through participation in figured worlds people can reconceptualize who they are, or shift who they understand themselves to be, as individuals or members of

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collectives" (p. 120). Thus, different figured worlds offer different possibilities for how people work to figure themselves (i.e., trying out new identities) and be figured (i.e., how contexts transform identities). The kinds of identity work that the figured worlds of classrooms support has recently been described as an equity concern in science education (Carlone et al., 2011). What it means to be a good science student in the classroom is a product not only of standard achievement but also of who one is allowed to be through the norms and routines that shape classroom life.

Identity Artifacts

We attend to *identity artifacts* produced by girls during identity work because they help us to recognize how identities are stabilized or objectified over time. Such artifacts are related to both the time scale and the spatial distribution of resources across these time scales (Wortham, 2006). Drawing on cultural historical activity theory, Leander (2002) argues that human activity is always mediated by artifacts of various sorts (e.g., material tools and signs) and defines identity artifacts as "instruments (material tool, embodied space, text, discourse, etc.) that mediate identity-shaping activity" (p. 201). We further posit that identity artifacts take various forms, including both material artifacts and semiotic signals (e.g., drawing, videos, re-formed songs, recurring/reifying verbal descriptions about an individual, etc.), produced during identity work that mediate the process of authoring self(s). These artifacts show the ways in which girls position themselves while engaging in systems of activities.

Identity artifacts also mediate recognition work. For example, Wortham (2006) describes how two students were habitually taken up as "beasts" and "outcasts." This repetitive process was purposefully linked to particular people and contexts—in this case, a joint English and history class—in ways that allowed meanings to build up interactionally over time.

Lastly, identity artifacts help us to understand how identities become stabilized over time. Leander, Phillips, and Taylor (2010) show how identities can be stabilized in a particular way among a range of available meanings because of how identity artifacts are configured across social spaces. The configuration of artifacts in space and time matters because the "social, cultural, historical use" and "transformation" of artifacts is situated in place and time (p. 203).

Tan and Calabrese Barton (2008), however, show how the stabilization of identities over time is also a powerful act of destabilization at the same time. They show how one sixth-grade girl, who, through repetitive processes, was interactionally framed as a "the passing student." One could pass or skip by her in class and it would not matter because she had "nothing to contribute." However, through her actions in taking on a new and playful persona in class—impersonating scientists and animals and telling

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funny but relevant stories—the same girl reconstructed an identity as someone who had important stories to tell that made science class fun and interesting. The act of reconstructing this new space for participation was an act of destabilizing her positioning as the passing girl.

Tracing Identity Work Over Time

Despite potential insights into girls' science learning and identity work provided by tracing identity work over time, few empirical studies have documented the trajectory of identification over substantial periods of time. We recognize both conceptual and methodological challenges in this task. No one could ever possibly observe all the identity work anyone does over time and space. However, we argue that girls' ongoing identity work can be understood in part by paying attention to key events that appear to carry meaning over time and/or space and how the products of identity work at one event are (or are not) transferred to other events. Such *traces* of identity work reveal girls' identity authoring practices that have enduring effects on their identity trajectory. One way of tracing identity work as suggested previously is focusing on identity artifacts and examining how the socially constructed meaning of self(s) in science mediated through identity artifacts at one or another key event are stabilized or transformed through other events over time. Another such way is by examining how individuals author and re-author identities in the moment at multiple points in time. Wortham (2006) refers to these kinds of re-authorizations that build over time as "interdiscursive objectifications" while Holland and Leander (2004) refer to this as "identity laminations." Both notions, however, point toward how identity associations hold power, "not merely because they are repeated, but because the repetition happens on a particular sort of occasion when being positioned just so is especially marked or re-markable" (Leander et al., 2010, p. 341). By carefully examining identity work across key events and by paying attention to the ways in which identity artifacts mediate the socially negotiated meaning-making of self(s), we intend to understand how and why girls from nondominant backgrounds author their identities in science over time.

Methods

Research Design and Activities

We employed a longitudinal ethnographic case study approach to study girls' identity trajectories over 3 years, from sixth to eighth grade. From January 2009 to December 2011, we followed 36 case study girls from two small Midwestern cities, one large East Coast city, and one Pacific Ocean city. Each of the girls attended schools that served a large nondominant population (i.e., students from underrepresented racial, ethnic, or linguistic

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backgrounds and lower income homes). We used a stratified sampling plan with a 20-cell design (2 × 5 × 2) that included socioeconomic status (low, middle), ethnicity (African American, Latina, Asian, Native Hawaiian, White), and science interest (high, low). To recruit girls for participation in the case studies, we first sought nominations from science teachers, then visited science classes and clubs to distribute information about the study that students could discuss with their parent/guardians. Study participation was voluntary. All case study girls had a history of participation in informal science clubs prior to the study. We opted for an initially larger sample size (N = 40) for case studies to allow for some attrition over the 3 years of the project.

Research sites were deliberately selected based on historical relationships, allowing for depth of knowledge regarding schooling and science institutional and cultural narratives. Additionally, we desired to conduct these studies in communities where we had established long-term relationships with teachers and family members, allowing for a more robust and in-depth look into girls' identities across the worlds of school, home, and club. Our research team was culturally and ethnically diverse, resulting in multiple perspectives and lenses for making sense of the case study girls' identity work and for relating to the girls themselves.

The case study girls represented different ethnicities, including African American, Asian, White, and Native Hawaiian, as well as low and middle socioeconomic status, although the vast majority were from lower income status homes. They displayed a range of competencies and interests in science. We followed the case study girls into science class, science clubs, other figured worlds of their choice (e.g., math, English, and music classes), and informal spaces (e.g., cafeteria, club, and home). Most of the data were collected during the 2010–2011 and 2011–2012 school years. For each case study, as primary data, we generated per year: (a) 56 to 90 hours of observation per girl across the three sites (home, school, and club), (b) interviews (2 hours/girl), (c) science artifacts from across the three sites, and (d) yearly digital "science and me" stories (see Table 1). Additionally, as supplementary data, we conducted interviews with teachers who worked with the girls in school and/or afterschool clubs and with the parents whom we could approach during the data collection either formally or informally.

Data Analysis

We developed initial portraits of each case study girl that included background information; their stories about current and future self(s), family, and science; and participation across different figured worlds at year one and then updated the portraits each subsequent year. To uncover girls' science identity trajectories, we focused on several focal events where girls actively appropriated resources and positioned themselves within figured worlds in ways that supported engagement in science. Sets of four or more focal

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Table 1
Data Generation Methods Across Sites

Data Form	Specific Data Generation Strategy			Description
Observation of girls' participation in different figured worlds and artifact collection	School figured worlds (i.e., science class, hanging out in science teacher's room during recess, etc.)			Each girl observed for 4 days a month (2 hours/day) for 6 months of the school year (48 hours/year)
	Science related but out-of-school figured worlds (i.e., Science Club, Summer Scientists program, tutor, etc.)			Each girl observed for 3 to 4 days a month (1 hour/day) for 6 months of school year (18 hours/year)
	Peer, family, community figured worlds (i.e., church, peers, work, etc.)			Each girl observed for 2 days a month (1–2 hour/day) for 6 months of school year (18 hours/year)
Interviews with case study girls	Views of science and self (year 1)	Views of science and self (year 1)	Views of science and self (end of year 2)	Interviews were semi-structured including both one-to-one and group interviews (2–3 girls)
Artifact think alouds	Classroom and club work (year 1)	Classroom and club work (year 2)	Retrospective classroom and club work (end of year 2)	Self-selected artifacts from each figured world used for think alouds interviews at least twice each year
Digital self-portrait (DSP) "science and me"	DSP version 1 (year 1)	DSP version 2 (year 2)	DSP version 3 (end of year 2)	At each succeeding year, previous version(s) of DSP were shown to student and reflected on
Interview with teachers and parents	Views of girls in school, club, or family (year 1)	Views of girls in school, club, or family (year 2)	Views of girls in school, club, or family (year 3)	Teachers were interviewed each year. Interviews with parents were conducted informally whenever we could approach to them.

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events per girl per year were identified by us by browsing the composite data sets and discussing events in weekly research group meetings. The identified focal events were the ones that stood out retrospectively because of how they were referenced in future activities over time or how they appeared to reflect a shift in a girl's perception of self and/or how others perceived her. We also asked girls to highlight key events that they felt shaped their science experiences. The first two authors wrote descriptions of focal events and analyzed the events using our figured worlds framework, including noting the (a) rules and norms, (b) tools and resources, (c) practices, (d) division of labor, and (e) object of work. Descriptions were shared over 6 months at weekly meetings and debated until consensus was reached on the interpretation of descriptions and the emergent claims. For each case study, we analyzed the girl's identity work for a range of events and during the meetings narrowed down our list to six focal events from sixth through eighth grade to allow for closer examination.

The first two authors then analyzed the roles girls played in each of the selected events, the ways in which girls drew upon resources, and the produced identity artifacts through the identity work. We paid particular attention to how both resources and identity artifacts mediated girls' engagement in the activities and the kinds of produced meanings about girls' self(s) in science. These "role, resources, and identity artifact maps" were then shared at group meetings over the course of 3 more months for further group analysis, discussion, and debate. Each girl's science identity trajectories were configured from cross-examination of the identity work.

We then used a constant comparative approach to analyze the data on comparable dimensions of girls' identities, resources, and participation in figured worlds across and within the research sites (Strauss & Corbin, 1998). Special attention was paid to how inter-figured world cross-leveraging of identities and resources differed across different groupings of girls, with a focus on the impact on girls' interest and performance in school science and attitudes toward a science, mathematics, and technology (SMT) trajectory. Comparative case methodology helped us to move the research beyond description to a theoretical understanding of the mechanisms that underlie girls' cross-leveraging of identities and resources for their interest and performance in science (Strauss & Corbin, 1998).

Findings

For this article, we purposefully selected two case study girls, Diane and Chantelle, as focal cases. We highlight these two girls' identity trajectories in science because they show two different kinds of identity trajectories that reflect contrasting and significant patterns that emerged from our composite data set (broadly speaking, girls whose engagement and participation in science increased and decreased during middle school, respectively). We also

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selected these two cases because their contradictory natures help us to describe the complicated process of authoring identity trajectories through the interaction between self and social contexts. Finally, these two cases were selected because they help us to interrogate how the matrix of race, class, and gender play an active role in the ongoing formation of identity trajectories. The purpose of our analysis is to offer a framework for "science identity trajectories" and to make sense of the identity work of girls with different science backgrounds and experiences. As Polman and Miller (2010) discuss, we intend to refine our framework and to develop conceptual tools that allow us to recognize girls' identity trajectories in science by examining the ways that girls' science identity trajectories were "particularized" (p. 887) using a small purposeful sample.

The stories are structured in the following way: Each case begins with a brief introduction of the case study girl, followed by descriptions of her identity work at a few illustrative events from different times (sixth, seventh, and eighth grades) and spaces (school, club, and home). After each case we synthesize our main points and then build a cross-case discussion.

The Case of Diane: Complex Contradictions

Getting to Know Diane

Diane is an African American girl who lived with her mother and two siblings during the time of our study. She wanted to be a lawyer or kindergarten teacher when she grew up. She shared many stories with us about how her family has positively influenced her. Her sister, who attended a local medical career center, taught her how to care for her body and how doctors keep track of health, such as through taking blood pressure, measuring one's breathing, and taking body temperature. She expressed a desire to follow in her sister's footsteps of working to save money for post high school education: "My sister works at McDonalds right now. She's going to school too. I want to do something like her . . . I just want like a part time job to start off with, and I'll get something better."

Over the years that we followed Diane, she was remarkably consistent in her views about science. To Diane, science was a way of understanding the world and a tool for solving problems. She engaged in science activities at home and enjoyed inquiring about the world around her. However, despite her ongoing interest in science outside of school, Diane never identified herself as someone who is good at science. Furthermore, Diane's interest and participation in school science drastically waned over the course of middle school, although she maintained her grades (Bs). As indicated in her contrasting self-portraits of "Diane in science," where she drew herself as a scientist doing an experiment in seventh grade and as a student sitting quietly at her desk in eighth grade, Diane showed a noticeable change in her interest, participation, and positioning in science over time.

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Diane's school science experiences stood in stark contrast to her experiences in English class. Diane consistently indicated that her favorite subject was English, where she enjoyed writing and reading. She was also an avid reader and writer outside of school, where she read newspapers and wrote poetry for fun. She said that no matter where she was, "if a line of poem comes up in my mind, I have to write it down." She wrote three hip-hop songs during the 2 years that we followed her and performed these songs for her mom at home.

Her performance in English class was stellar. Not only did she receive "A-plusses" but as both she and her teacher noted, she was always prepared, never missed extra credit work, and finished tasks with high quality, although slowly. In English class, she did not hesitate to ask questions and explained her thoughts to her teacher before she answered questions.

Diane's case reflects the dominant pattern found in previously published studies—that of decreasing levels of engagement in school science among girls during the middle school years. This case, however, also reveals the complicated and contradictory picture of identity work that is not very well captured in the description of this overall pattern. In other words, Diane is easily (and unfairly) pegged as a girl with little interest in and in need of academic help in science. And yet, as the case reveals, Diane enjoyed science and engaged deeply with the subject matter in school in ways that seemed to become hidden by the normative practices of schooling.

Diane's Identity Work in Science Between Seventh and Eighth Grade

Locating identity work in multilayered figured worlds. Diane attended a large middle school in a small city, where, in 2010, unemployment rates were much higher than the national average (15.9% in 2010 according to the U.S. Department of Labor) and where schools have been consistently underfunded. Her school housed over one thousand seventh and eighth graders, about half of whom were White, 40% African American, and the remaining 10% Hispanic and Asian. There was racial unease in the city and in the school. De facto segregation appeared to occur through course scheduling, which was supposedly based on student ability in literacy and math, but tended to look more like it was based on race. The newly appointed assistant principal mentioned to us in a conversation that he thought that race was a problem in his school and that the faculty and administration had to come to terms with it. These race-based groupings appeared to spill over into how students configured themselves at lunch and in other informal spaces.

Diane was in one of the highest ability groups for the seventh grade, making her one of only a few African Americans in her section. Her science teacher, Mrs. D., was a dedicated teacher who had been recognized as "best

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teacher" at the school, district, and state levels. Mrs. D. was known for telling stories in the classroom and for trying new things such as curricular materials developed by a university-based research team.

Mrs. D. also ran the lunchtime science club in which Diane participated in seventh grade. Initially the science lunch club started with 10 girls—5 White, 3 African American (including Diane), and 2 Asian girls, all with various school performance levels and family background—and was fairly representative of the student population of the school. However, as time went by, the club became dominated by middle-class White girls who began to bring their friends into the club. Slowly the 3 African American girls dropped out. Diane stopped coming to the science lunch club at the end of seventh grade, at about the same time that her friend, one of the White girls in the club, transferred to another school. When we asked Diane why she stopped attending the club, she said that her close friends, who were all African American, wanted her to stay with them at the cafeteria during lunch time. She noted this was one of the few times during the school day she saw her friends, as most were in other sections.

Using science to figure things out and learn new things in seventh grade. Diane thought of science as "figuring things out using her brain." She was interested in understanding the things that happened around her as well as the meaning of words that she encountered. We observed many instances of Diane using the space of school science to figure things out and to be curious.

For example, early in seventh grade, Diane's class made model rockets and competed for how far and fast their rockets flew. She thoroughly enjoyed the project, spending time designing her rocket perfectly. She won a prize because her rocket went the furthest in the contest. And yet, while she recalled the event with vivid detail and excitement, her peers did not remember it. In fact, during an interview later that year, Diane and her peer Michelle argued about who won:

> Interviewer: And who went the highest do you remember?
> Michelle: It was two boys that won the highest and the farthest.
> Interviewer: The same boys who won the . . . ?
> Diane: No, I went the farthest.
> Michelle: You were the second one cause um Avery won the farthest and . . .
> Diane: No, I won the furthest.

Despite the lack of recognition that Diane received for her efforts, her interests in science remained consistent across spaces and were not limited to any one topic area. When the class compared butterfly development on earth versus on the space station, Diane frequently checked the butterfly larva in the back of Mrs. D's classroom during the school day. She spoke about her curiosity regarding their development and wanted to keep a close

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track on their growth. Diane actively shared many stories in science club, such as ones about her understandings of and experiences with butterfly life cycles and fossils. In her digital story "My Life . . . And Science," Diane referred to an activity of her science lunch club: "To me science is like a project. It helps me learn more new things, for example: we do experiments outside like when we put sun block on bracelets and they changed color's [*sic*] in the sun. It is not hard to use science. Science is all around you, when you go outside, you are using science."

At times, Diane's efforts to engage in science through inquiry positioned her negatively with respect to her peers and teacher. In a lab on forecasting rain, students worked in pairs to make predictions about rainfall. The process involved measuring the number of water drops a cotton ball would absorb before it started to leak. Many of the students in the class finished early, allowing them free time at the end of the period to socialize or to work on other assignments. Diane, who partnered with a shy White girl, began by getting the materials and reading the worksheet out loud and carefully with her partner. Diane and her partner changed roles on each iteration of the water drop activity so that both had turns holding the cotton ball and dropping the water. After carefully repeating the process of making predictions and measuring, Diane wrote, "Clouds can hold a lot of rain till it has to burst"; "Your guess that if it's going to rain or not is not always right." She and her partner finished up the assignment just as the class bell rang. This stood in contrast to the class leaders who finished earlier and only wrote a single response on the worksheet, "They're all different and unpredictable."

Yet, despite her self-expressed excitement about doing science and our observations of her thorough and meaningful engagement in activities, Diane did not think of herself as someone who was good at science (i.e., ranked herself a "4 or 3" out of 7 in seventh grade). The students she identified as "good at science" were the ones who received As in school science, finished their assignments early, and "understood every word [Mrs. D.] says." Diane expressed her difficulties in understanding the "big words" in science class. She said, "Usually I need help."

> Diane: Like, on some of the papers we do, like [Mrs. D.] explains it, I just don't get it. And she says you do something. I'm like, I don't get what she's talking about . . . like at first she just said something and I didn't understand them. She used some big words . . .
> Interviewer: You remember any of those big words?
> Diane: I can't even say them. I don't know . . .
> Interviewer: Ok, Ok. But it was just these big words you were like, "Ah I don't get it." ok.
> Diane: And I just acted like, I could go along with it. And when I looked at the paper, I was like, "I need help" right away.

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Diane enjoyed doing science and working with partners to figure things in science. She participated in activities as a coworker when she worked with her friends in her science class and science lunch club. Interestingly, however, Diane never positioned herself as a good student.

Being a "B" student in science in seventh grade. The analysis of Diane's identity work indicates that the ways that Diane viewed herself in/with science slowly changed throughout the seventh grade. Although Diane was still interested in figuring things out and liked to work with partners in her science class, she struggled with scientific terminology. She continued to take her time on assignments, grasping ideas in depth, although almost always finishing her work last. She continued to lack significant recognition for her science interest or understanding by her peers and teacher. Mrs. D. enjoyed Diane in class, but did not think of her as a good student.

Despite her interest in science, Diane had few formal opportunities to pursue science projects. While she wanted to attend family science night, she could not because her mother had to work and she had no other transportation. As mentioned earlier, Diane also stopped coming to science lunch club toward the end of the seventh grade. In science class, Diane expressed little concern about her grades and often chose not to do extra credit work. By the end of seventh grade, Diane positioned herself a "B" student, who *did not need to* be and presumably *could not* be excellent in science. As described previously, during the last week of one of the marking periods in seventh grade, Diane opted to take the B+, telling us that, "I got As and Bs. I don't need all As."

Alienating self by drawing "weird things" in eighth grade. Diane was placed in a medium ability section in the eighth grade. She should have been placed in the high ability section, as she had been the previous year. We were told that because she opted out of band class (a class with extra fees that her family could not afford), she was rescheduled into the medium track class. This track landed her in Mrs. E.'s science classroom. Mrs. E.'s instructional approach differed from Mrs. D. in ways that worked against Diane's opportunities to engage in interesting science activities. In Mrs. E.'s class the students were expected to take careful notes during her mini lectures. Diane was frequently observed drawing what she called "weird things" such as various forms of circles and curved lines in her science notebook or on scratch paper while her teacher talked. As she stated, "I just draw weird things, like when I just get bored and just start drawing on the paper." While Diane loved to write, she felt that writing science was different, primarily because of the big words that carried little meaning for her.

We were interested to visit Diane when her eighth-grade class was doing a lab activity, as these were the spaces where we noted Diane's science interest really shone in seventh grade. One class session, in particular, stood out to us because of how quickly Diane shifted her positioning in science class as a result of the activity. At the beginning of the lesson, the teacher

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distributed a worksheet that consisted of a list of questions about light, such as "What is light? Can you see it? feel it? hear it? How many different forms of light are there? How many times have you used light today?" Diane did not answer the questions, but instead drew various figures to describe her ideas. Following the worksheet, the students observed the fluorescent lights hanging on the ceiling with a spectroscope and recorded their observations. Diane excitedly grabbed one spectroscope and carefully observed the light. When Mrs. E. asked the class, "Do you think the colors have certain order?," Diane, who rarely spoke in class, immediately volunteered, "Red, orange, green, blue . . . ." Mrs. E. built on Diane's response and asked the students to look again at the light. Then she commented, "If you have any questions about the light, write them down on the worksheet." The bell then rang, and most students quickly wrapped up their work and left the classroom. Diane, however, stayed past the bell to observe more. Finally she spoke to herself, "There is a big circle in the middle . . . the big circle is a pattern, okay!"

We began to see that this kind of participatory behavior pattern was typical for Diane. That is, when science class was structured around a lecture or activity sheets, Diane often alienated herself from the large classroom community by talking with friends near her seat or by drawing. However, when the class engaged in projects or labs, Diane often became animated. We noticed that when she worked alone, such as with the light activity just described, she tended to engage with the work more deeply, as we saw with the light observations. However, when she worked in small groups, she tended to take on the more passive role of observer, rather than leader, as she often performed in seventh-grade science group work.

When we asked her about these patterns, Diane described herself as a "bad" student in science class, saying "[In science class, students] talk a lot, they're bad. But I'm part of it, so I talk." Diane ranked herself as 2 out of 7, much lower than her seventh-grade year (4 out of 7). She described herself in science as someone who was "sleepy, talkative, and drew a lot." Diane said that she did "not like science."

Summary of the Case

Diane's sense of self in science shifted across middle school. Her level of excitement, interest, and perceived level of competence gradually decreased, although her official grades in science remained consistent (Bs). Noticeable shifts came in the role she played in group work and in whole class discussions, where in seventh grade she actively volunteered to share her stories and typically played the role of a coworker in order to figure things out to eighth grade where she became an observer or someone who was distracting the teacher.

Despite the fact that Diane maintained a strong science identity from one particular point of view (she still liked experiments), Diane did not think of

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herself as a good science student nor did others view her that way. The figured worlds where Diane's identity work took place were compartmentalized and closed off from one another in that Diane's identity artifacts (e.g., rocket, poetry) were not transferred or capitalized by others across figured worlds. Furthermore, the figured worlds were painted with race and class power dynamics, further pushing back against Diane's efforts to engage science meaningfully. Diane's identity work seemed to lose momentum gradually when she had to continuously make choices between competing memberships among different figured worlds, when structured activity in classrooms positioned language as the mediating factor in science learning, and when her efforts and abilities in science were not recognized or were devalued (see Table 2 for summary).

Chantelle: On Becoming a Green Energy Science Expert

In the eighth grade, Chantelle, an African American girl, aspired to become a "green designer." In her words this allowed her to combine her love of the arts, interest in science, and desire to make the world a better place. This was a fairly new career aspiration for Chantelle. When we first met her, in the summer following fifth grade, Chantelle wanted to be a professional dancer or singer. Over the more than 3 years that we got to know her, Chantelle attended an urban K–8 magnet school for the arts. She appeared quite happy at that school because "it gives [her] what [she] needs" to succeed in life. Chantelle's identity work in science—and the possible futures she authored for herself—pose interesting questions about how youth, and in particular African American girls, can buck the trend of waning interest in the physical sciences in the middle grades. Unlike many girls her age, Chantelle's interest and success in science has grown throughout middle school.

Getting to Know Chantelle in the Beginning of Sixth Grade

We first met Chantelle in the sixth grade. As a tiny and soft-spoken girl, Chantelle seemed to easily disappear from view in science class. She was infrequently called upon to contribute and rarely, if ever, got into trouble. Chantelle's sixth-grade teacher spoke highly of her as someone who listened. Her teacher described her as an "easy" student who is "great to have in class," a "student in the middle," and someone who "struggles to understand concepts, especially in math." She received average grades (mostly Bs and Cs) in her classes. Her science and math grades were lower than her grades in literacy and social studies (her two favorite classes).

Chantelle hung out at a youth center each day after school and had done so since second grade. Her mother, who worked full-time for the city's department of transportation, felt the youth center provided Chantelle with a safe place after school where she could receive tutoring. Her mother appeared to be a strong advocate for her daughter's education and remained

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Table 2

Summary of Diane's Critical Moments (the "Beads" of Figure 1: Identity trajectories)

	Grade	Event	Figured Worlds and Resources	Identity Artifacts	Identity Work
Diane	Seventh	Measuring the size of butterfly larvae in a space station February 2010	Science class at the computer lab	Opts out doing work for extra credit	Positions herself as a not caring student; questioning the meaning of the task Recognized as a resistant/not focused student by teacher
	Seventh	Discussing the life cycle of butterfly February 2010	School lunch club	Shares stories about butterfly larvae	Positions herself as a good contributor Recognized as a social girl who likes to talk
	Seventh	Forecast rain activity March 2010	Science	Forecast rain worksheet	Positioning herself as a co-\worker Thoroughly engaging in scientific practices
	Seventh	Snowfall data analysis activity, March 2010	Science	Thoroughly inquiring the phenomenon	Positions herself as not-caring participant Opts to do what she is interested in at the expense of getting the work done in time Recognized as a slow and less smart student who did not get the extra credit
	Eighth	Mrs. E.'s lectures on energy November 2010	School	Doodlings on the papers	Positions herself as a bad student Alienates herself from the large group Recognized as an unfocused, distractive African American girl

(continued)

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Table 2 **(continued)**

	Grade	Event	Figured Worlds and Resources	Identity Artifacts	Identity Work
	Eighth	The unit of light January 2011	School	Drawings on the light worksheet	Positions herself as an illiterate student in science Recognized as a less capable student in science
	Eighth	A small group work about pendulum February 2011	School	Pendulum worksheet	Positions herself as an observer in group; thoroughly engages in the activity Recognized as a student in the middle
Chantelle	Sixth	Science exam October 2009	Science class	Exam	Activity positions herself as good student and silent/invisible participant
	Sixth	GET City Chant October 2009	Afterschool club	Uses dance to gain voice/authorship in science club	Positions herself as a good contributor Recognized by teacher for her dance contributions
	Sixth	Light bulb stories November 2009	Afterschool club and home	Uses stories and acting to incorporate home experiences into science club	Positions herself as a knower and doer of science Recognized by grandparents and teacher as someone with important stories and ideas
	Sixth	Light bulb audit November to January 2009–2010	Afterschool club and school	Make a Change video	Positions herself and recognized by others as science expert and make a difference expert among her peers out of school

(continued)

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Table 2 **(continued)**

Grade	Event	Figured Worlds and Resources	Identity Artifacts	Identity Work
Sixth	Student congress workshop and classroom teaching January 2010 and April 2010	School and afterschool club	Make a Change video	Positions herself and recognized by others as science expert and make a difference expert among her peers and teachers in school
Seventh	Energy Efficiency March 2011	School	Expert stature	Positions herself and recognized by others as expert in the classroom
Seventh	Green Carnival April 2011	Afterschool club, school, and community	Expert stature	Positions herself and recognized by others as expert in the classroom and community

in contact with her teachers at school and at the center. We observed her mother making encouraging remarks to Chantelle such as "make sure you work hard" and "get your work done." Chantelle always nodded appreciatively.

Chantelle viewed the youth center as a "home away from home." It was there she joined the Green Club because her two friends had joined the year before and they "talked her into it." She said that she was not so much interested in science, but her friends told her "it was not like science class" and more like "doing research and stuff" to "improve the world."

Locating Chantelle's Identity Work in the Multilayered Figured Worlds

Finding safety through invisibility in the world of school science. Chantelle's middle school science classes were all fairly traditional in design and orientation. All were organized in rows and were typified by small lectures, group work on activity sheets, and behavioral expectations. In sixth grade and through much of the seventh grade we never observed Chantelle volunteer to speak in science class.

Typical participation for Chantelle appeared not to waiver much. She always got her work done on time. She listened to her teacher and peers. She tended to ignore the students who were disruptive. While in group work, we never saw her lead the group, but she always appeared helpful, playing the role of recorder or observer. One day when her class was preparing to take a test, the teacher asked if anyone had questions. Chantelle raised her hand, which surprised us. When called on she reported that she was absent the day before and did not know there was a test. When the teacher responded by telling Chantelle that she could have a copy of the review sheet, several other students chimed in that they also did not know about the test, causing some chaos. The teacher responded forcefully by repeating several times that "There shouldn't be anyone talking or communicating right now."

The event seemed to silence Chantelle. Some students cracked jokes in what appeared to be an attempt to stall the test administration. Usually Chantelle was engaged in this kind of banter. This time, however, Chantelle separated herself from the class, putting her head down, almost protecting herself with her silence. While this episode showed Chantelle in an even more reserved role than is typical in her classroom, we feel it demonstrates well how she often used good behavior and silence to create a safe space in the classroom for herself.

Taking on a science identity in after school Green Club: Acting and dance as science identity work. Chantelle's engagement in the after school Green Club in the fall of sixth grade mirrored her school science participation in many ways. She would miss Green Club sessions if it conflicted with dance practice. When she came to Green Club, she was there on

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time, and almost always entered the club meetings with her two friends. They would usually sit at one of the side tables, grab their computers, and get to work.

Early on in the year, when Green Club participants were discussing whether they wanted a chant or slogan, Chantelle was one of the first students to raise her hand and offer an idea. When called upon, Chantelle stood up and performed a dance along with repeating rhythm, "Green Club! Green Club!" When asked to do the dance again, she stood up and did it again, more slowly to help the group see her moves better. This episode stood out to us because it revealed that Chantelle was not necessarily as quiet or shy as some of our observations in school suggested. Here, she appeared to see an opportunity to contribute to the club based on something she perceived herself to be good at and was recognized by others as being good at—dance.

A month later, the youth in Green Club began investigating the statewide campaign, "Change a Light, Change our State." This campaign was focused on getting residents to change their incandescent light bulbs for compact fluorescent light bulbs (CFLs). While the youth explored the science behind the campaign, they were each also given six CFLs to replace the incandescent bulbs they had at home. During that time, the club began each week with youth stories about when, where, and why they changed their bulbs. The first week Chantelle did not volunteer a story. The second week she told the group how she and her mom did an audit of the bedrooms and found out that they had "8 dinosaur" bulbs to replace. In telling her story she impersonated her mother pointing out "dinosaur" bulbs. She then said she and her mom replaced the old bulbs with the new bulbs. After club that day she asked for more new bulbs to bring home. The next week, Chantelle volunteered another story about changing bulbs at her grandmother's house, this time playing out the roles of both her grandmother and grandfather.

> Chantelle: My grandmother had a lot of incandescent bulbs. We put in 18.
> Teacher: What did your Mom, or Gramma say [when you put in 18]?
> Chantelle: My Gramma, she had helped us, but my grandpa says "*What are you doing to my light bulbs?*" But my grandmother says "*Sush, she is doing work.*"
> Teacher: And did you explain why it was important to change light bulbs?
> Chantelle: Yep!
> Teacher: Good, and you said what?
> Chantelle: I explained to him why it was important to change light bulbs because you wasting money.
> Teacher: And then he said what?
> Chantelle: *Get back to work then*!

Here we see Chantelle using stories to begin to engage in scientific talk. She acted out the episodes at home. We think her use of the term "dinosaur

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light bulb" in the first story and the shift to the more technical terms of incandescent ("dinosaur") and CFL ("new") bulbs in the second story suggests increasing confidence in taking on discursive practices commensurate with her developing sense of self in the club as someone who can do science.

Expanding access to science through dance and playful acting. Dance choreography and acting continued to play an important role in how Chantelle found ways to engage in the work of Green Club over the course of middle school. Later in the year, Chantelle and her two friends conducted a light bulb audit at their school. They wanted to see how much energy and money their school was wasting by using incandescent light bulbs. Saving money was important to them as budget cuts at their school loomed. They counted the number of incandescent bulbs, documented their kilowatt hour expenditure, and then calculated how money and CO_2 emissions would be saved if they replaced those bulbs with CFLs. They used a video recorder to document the process and to interview teachers and students on the topic. Chantelle's two friends led the group, organized the spreadsheet, and made the suggestions for where to go in the building. Chantelle took up the role of pointing to the light bulbs in each video shot. In each classroom and bathroom the three girls provided commentary on video. Footage revealed Chantelle's two friends offering the explanations regarding energy efficiency and conservation, with Chantelle adding gestures and acting out the ideas in the background.

Chantelle's role in her group took on critical importance when the girls began to edit the video into a short documentary. Chantelle directed the editing, and as the two other girls wrote up explanations for each part of the movie, she carefully choreographed each new scene. Later, as the group began to run out of time to finish the movie, Chantelle took over editing the film in her spare time. Chantelle ended up selecting most of the music and came up with most of the suggestions for how to make the video catchy. For example, the opening scene, played to the chorus of John Mayer's *Waiting on the World to Change*, was rehearsed many times outdoors on a cold winter day in the upper Midwest and involved carefully choreographed moves.[1]

It was Chantelle's idea to have a scene that referenced the energy-efficient CFL, "It's just 13 watts," replete with funky music and quick transitions repeat between clips of classroom visits. In another sequence connecting across several science parts, the girls moved from explaining the burning of coal to the use of light bulbs to greenhouse gases and climate change. The video started with one of the youth narrating the following exchange before transitioning to an image of a yellow warning sign with the large letters "CO_2" and smaller text "Climate Change" within the "O" and followed by an image of the Earth on fire in the palm of a hand:

> Friend: Not only do they give us pollution but they also release carbon dioxide.
> Chantelle: You know CO_2.

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> Friend: The problem with greenhouse gases, like CO_2, is that they contribute to climate change.

Chantelle's participation in making the movie seemed to refigure her in Green Club as an expert. Her time with the movie, initially made possible through her artistic contributions, provided her with extended opportunities to engage with the science content of the movie.

Refiguring the strange world of school/ science. Several interesting events occurred after the light bulb audit. The light bulb audit created a big stir among the youth in Green Club. They wanted to use the movie to make a real change at their school. With the support of the school principal, the youth presented a workshop to the school's student government. The workshop was built around the light bulb audit movie, and Chantelle and eight other girls copresented their ideas. At the workshop, Chantelle introduced the movie at the beginning of the workshop and then at the end of the workshop presented a pledge to the student government and school leaders, asking them to indicate their willingness to change the school's incandescent bulbs to CFLs.

After the workshop Chantelle asked if she could present the same workshop to her science class. Her teacher agreed, but indicated she had to wait until Earth Day to do so. So, 3 months later, Chantelle presented the workshop to her class with the help of one peer. This kind of participation stood in stark contrast to her everyday participation in science class, where she was fairly invisible. What stood out was not simply that she presented the material, but in how she engaged the class. She began by asking her peers questions about why they should care about light bulbs and positioning herself not only as the expert but also as someone who cares about them and about the connections between science and their worlds.

If this were a stand-alone performance we might take less notice. However, we saw a new pattern of participation in the classroom emerging for Chantelle, revolving around her work as a green energy science expert. When her seventh-grade class studied energy transformations in March 2010, her teacher started class by asking the question, "What types of energy transformations happen during a roller coaster ride?" Chantelle raised her hand and was called on but her response was fairly inaudible. The teacher seemed confused and then said, "Energy is not created but there is energy when it is moving." Chantelle responded by saying that "But, buses that have solar panels are the most energy efficient because it gets energy from sun. They are green machines." The teacher then asked her to explain what she meant by efficient. Chantelle described the energy transformations she learned about in Green Club, including how incandescent light bulbs are not efficient because they transform energy into heat instead of light. She mentioned how green energy buses are more efficient and cleaner and thus better choices, although she was not prompted to explain how or why

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she thought that. Instead the teacher commended Chantelle's thinking and told the class that he learned something from her. He referenced her example as other ways that energy gets transformed in our everyday lives.

That same day, both Chantelle's teacher and the teaching intern in the classroom had very positive things to say about Chantelle. In March, her teacher who had earlier described Chantelle as quiet and struggling was now saying that he wanted to "clone" Chantelle and that he wished that "every student were like Chantelle" because she was smart, a hard worker, and engaged in science. These kinds of performances on Chantelle's part were observed on several occasions in the latter part of seventh grade and during the eighth grade. Chantelle's mother commented to us shortly after the end of the school year:

> You have no idea the difference Green Club has made in my daughter's life. She ran for student council this semester and even though she didn't win, she wrote a great speech and handled herself really well. I was so proud of her and there is no way she would have done that if it wasn't for Green Club. She was a girl who didn't talk until she was 4 and then she hardly spoke at all. And now she is getting up in front of people and giving speeches and more.

Summary of the Case

Chantelle's sense of self in science shifted noticeably across middle school. She shifted from wanting to be a dancer to wanting to incorporate the arts with science. She increased her participation in Green Club and school science in ways that, over time, positioned her with epistemic authority. Her teachers shifted from viewing her as a student who struggles to a student they want to clone. Noticeable shifts came in the roles she played in group work and whole class discussion, where she initially rarely volunteered to speak and played the role of helper, but later began actively teaching her peers and running for student congress.

Her developing sense of self in science had traces in opportunities to incorporate dance and acting in science, especially when those opportunities were positioned as (a) valuable and important to the learning community at the moment (e.g., recognized by others as important) and (b) significant to the science work at hand (e.g., constructed by others as a part of the science narrative). These opportunities became reified socially as science identity artifacts—as concrete actions, events, and things—represented and positioned her as a science expert.

Chantelle's identity work gained momentum across figured worlds when she or well-positioned others recognized and leveraged her identity artifacts (dance, videos) toward new action, further stabilizing her science expert status, and introducing new resources into previously less supportive worlds. Chantelle's identity work also gained momentum because her figured worlds seemed easily mutable, with her school teachers taking up

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her Green Club work. Further, it is not surprising to us that Chantelle's critical identity work took place after school where the activity system of Green Club allowed for flexible roles and supported important repositioning (see Table 2 for summary).

Discussion

How do Diane's and Chantelle's stories inform our efforts to better understand the ongoing science identity work of girls from nondominant backgrounds? In our discussion we take on two main points that speak directly to our research questions. First, we examine the roles of space and time in girls' identity work. Using the girls' stories, we examine how their ongoing identity work configures particular identity trajectories, and we explain both how and why we think such configurations matter in light of intersectionality and equity-driven concerns. This kind of analysis requires us to keep the analytic grain size focused on "identity work in the moment," allowing us to understand identity trajectories retrospectively.

Second, using a retrospective view, we then shift the analytic grain size to the identity trajectories themselves and discuss critical shifts in each girl's trajectories, making sense of the mechanisms that foster those shifts. The stories of Diane and Chantelle, as representative of our composite set of cases, suggest that girls' science identity work creates traces that open up or constrain their future possibilities. Those traces are generated as the actions girls take and the relationships they form are recognized by others in particular ways and (de)stabilized through identity artifacts that move across space and time. We look at how this process influences shifts in identity trajectories through the ways in which girls are able (or not able) to layer new meanings of selves and of science with the re-configuration of figured worlds.

Authoring Science Identity Trajectories: Traces of Identity Work Over Time and Space

The findings of this study call attention to how and why identity work is cumulative and sometimes contentious as it occurs with and against personal desires and cultural historical narratives of the figured worlds in which it takes place. Moments of identity work crystallize in time and space in ways that both de/stabilize who one is and how one is positioned vis-à-vis local people, practices, and historically institutionalized struggles (Eisenhart & Finkel, 1998).

Diane, despite her best efforts to engage in science for meaningful learning, was consistently positioned as slow and as not caring about school success in normative terms, although more so in eighth grade than seventh. The figured worlds of seventh and eighth grade school science grew increasingly tighter in the ways in which they valued expediency and getting it right over slower, more purposeful efforts to think about the science at hand. While seventh-grade science offered Diane opportunities to think and do science

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through frequent project work and greater flexibility in assignment completion times, eighth-grade science offered few of these possibilities. Even when labs were conducted in eighth grade, Diane's contributions were valued for being right rather than being interesting or thought provoking. What is more, with an historical practice of ability tracking in the broader figured world of her school that often materialized across racial and class lines, and as one of the few African American girls in her higher achieving section, Diane frequently opted to lunch with her African American friends, ultimately eschewing science lunch club when the White girls took over, which further (and unfairly) positioned her as disinterested. Each of these moments of identity work, in school and science club, built on each other across the seventh and eighth grades, stabilizing an identity trajectory that moved further away from science.

Chantelle, on the other hand, participated in the figured world of an afterschool science club that considered her artistic ability an asset to doing science well, opening up new and different opportunities to try out being a science expert. While the demographics in Chantelle's school were fairly similar to Diane's school, the youth in Chantelle's afterschool club was predominantly African American. The club leaders, over time, also built a culture of high expectations and frequently talked with the youth about the problematic nature of racial and gendered stereotypes regarding who likes or does well in science. Youth in the club expected that they would be "community science experts" who made real differences in their communities. Her club became known at her school as a place where cool, exciting, and important work was done. Further, as she attended a magnet school for the arts, her video documentary made in afterschool was well received in school as a reflection of the school mission: to incorporate the arts into the study of all subject areas. It opened up opportunities for Chantelle to use her expertise in novel ways, positioning her as a science expert while also showcasing her artistic talents, of which she was very proud. For Chantelle, each of these moments of identity work, across the spaces of after school and school, built on each other, destabilizing the notion that she was a quiet girl with academic struggles while simultaneously stabilizing her interest in science.

As Diane's and Chantelle's stories indicate, the actions girls take, the relationships they form at any given moment, and the ways in which these are recognized by others leave particular traces in time, as the girls progress through middle school, and in space, as their identity work moves across the various figured worlds of school, afterschool, and home, among other figured worlds. These traces are ascribed meanings socially as a result of personal and institutional histories, and as these traces accumulate in time and space meanings gain or lose traction. We think of the accumulation of these traces, or in other words, these reified moments of identity work in space and time, as "identity trajectories." One's identity trajectories not only

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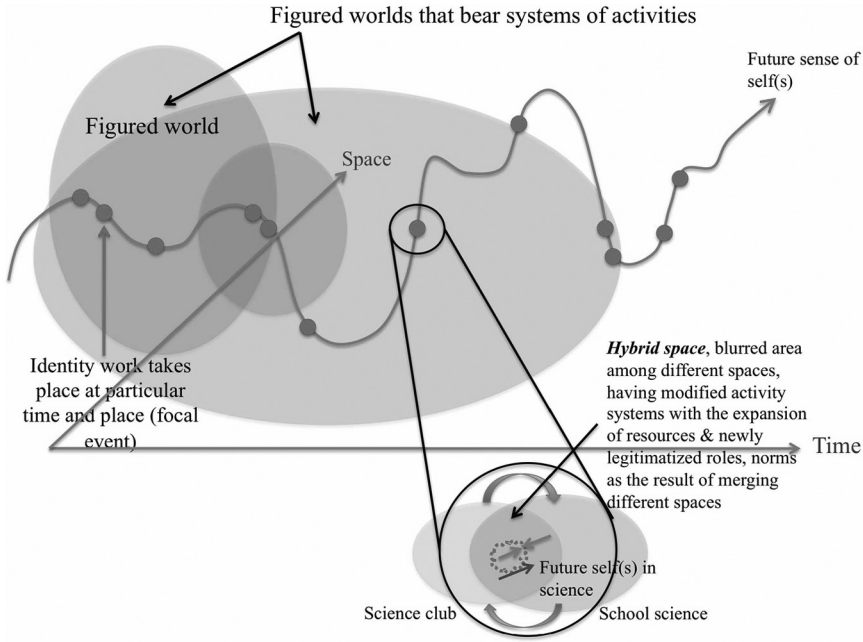

Figure 1. **Configuring identity trajectories.**

capture the evolution of identities from past to present and across figured worlds, but also one's momentum toward future self(s) reflected in current identity work. It makes sense then that identity trajectories can only ever be configured retrospectively through understanding identity work in the moment as both an effort to become a certain kind of person in a moment and in its associated recognitions by others.

In Figure 1, a girl's identity work at any given moment, which is represented by the red beads, is situated in multilayered figured worlds, or the spaces that girls inhabit. Each figured world has its historically legitimized norms, rules, resources, and practices that play a role in the cultural production of what science is and what it means to be a science person. They also shape the ways in which girls express "meanings of" and "affiliations with" being scientific (Carlone et al., 2011, p. 461).

At any moment of identity work, girls' identities bear momentum toward their future sense of self(s) in science that drive them to interact with individuals in a particular way when engaging in activities. We represent this idea of momentum as "arrows" for each bead in Figure 1 that vary in length and direction at each moment of identity work. As Wenger (1999) discussed,

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"identity is not static, thus [identity] trajectories are not pathways but rather a constant motion," "one that has momentum of its own in addition to a field of influence" (p. 154). We think that the momentum reflects students' current resources and strategies of action that are rooted in their previous science-related experiences in various worlds. The momentum also reflects girls' sense of their future self(s) in science, the ways in which they see themselves in/with science in their future lives (e.g., I need science to be a veterinarian). Momentum also reflects how girls' actions and intentions are leveraged, missed, or marginalized by others. For example, in early seventh grade Diane exhibited strong momentum toward engaging in science. Her momentum was rooted in her previous experiences of doing and using science to learn new things, but her limited resources (e.g., lack of scientific vocabularies) and her current strategies of action to activate available resources (e.g., not asking questions of Mrs. D. until she really needed to) impacted Diane's action at the focal events. Chantelle also showed a momentum of being someone who contributes in classroom discussion while positioning herself as a science expert regarding the issue of green energy at a focal event in the latter part of her seventh grade and later in her eighth-grade year. The analysis of Chantelle's identity work suggests that her momentum was deeply rooted in her experiences provided through afterschool science club and in her position in a magnet school for the arts. The momentum of this focal event also reflects Chantelle's sense of her future self(s) in/with science—being a green building designer.

Looking closely at the kinds of resources and strategies of action that girls take to leverage those resources point toward how and why identity trajectories develop over space and time. What matters in addition to the kinds of resources leveraged, however, are the ways in which these resources become points of social negotiation and symbolic representations of critical identity work. For example, Chantelle drew upon her interest and talents in art to negotiate a meaningful space in after school science. This resource was readily acknowledged by others in the creation of the movie, repositioning her as a powerful contributor. Later, Chantelle asked to show her movie in her classroom to teach her peers about energy efficiency. The movie became a symbolic artifact of Chantelle's science expertise and power in school, as it was referenced by teachers and peers alike. It was shortly thereafter that Chantelle decided to run for student congress, where she felt she could make real change. Her mother described this decision as transformative for her daughter, something that changed how she viewed her role in school and in how others perceived her. For Chantelle, and for the rest of the girls in our study, resources take on symbolic meaning as they transfer longitudinally (e.g., from past to present) and spatially (e.g., from out of school activity to in-class activity). In Diane's instance, however, we can see how a lack of recognition of critical identity-leveraging resources impacts Diane's identity work *against* her efforts. Recall how Diane's winning rocket entry, which

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meant a lot to Diane for she talked about it as an example of how she solves problems, was not remembered by her peers. Also recall how Diane's invasive species poster, because it was turned in last and incomplete, reflected Diane's efforts to understand but symbolized her slowness and what her teacher perceived as her lackluster ability in science class.

The ways in which resources are accessible to and activated in girls' identity work reveal how the structures of power, privilege, and oppression in the figured worlds in which girls participate impact identity trajectories. As pointed out with the notion of intersectionality, girls' identity work is always subject to power relations, as any figured world has legitimatized norms, rules, and culture of practices. Diane, who initially held strong science identities, had to respond to the backgrounded figured world of her school where there existed hidden hierarchies between middle- and lower-class students, between White and African American students, and between normative school science practice and the practices of science brought by individual students. Diane felt that she had to make a choice between competing memberships (i.e., participating in science lunch club that was dominated with White middle-class girls vs. staying with her core group of African American friends during the lunch time) as she traversed across figured worlds. The activity systems of Diane's science classes were also laden with their own norms, rules, and expectations, which put Diane's practices (e.g., spending time to think and figure things out) in a lower hierarchy. However, Chantelle was propelled to the top of the class, in part because the new resource that she brought with (her movie) could be activated without friction as the new resource embodied the school mission of integrating the arts into academic work.

In short, both cases demonstrate that girls' identity work is contentious and cumulative and that it happens with and against the structures of power, privilege, and oppression. Examining the ways in which resources are transferred, expanded, legitimized, accessed, and leveraged by girls and others over time and space helps us understand how and why trajectories of identities develop in particular ways.

Shifting Identity Trajectories in Science: The Nature of Shifts and Its Mechanisms

In this section we shift to a retrospective view to discuss critical shifts in girls' trajectories, making sense of the mechanisms that foster those shifts. Across our composite data set, many, but not all, of the girls made substantial shifts in their science identity trajectories over the course of middle school. What we mean by "shifts of science identity trajectories" is that a girl comes to view herself in science in a different way and others come to view the girl in a different way while engaging in science-related activities at particular moments. While the shifts can be described in many ways, we are most

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interested in those shifts that reflect increasing or decreasing interest, perception, and participation in science.

We view these shifts differently from inbound and peripheral identity trajectories discussed elsewhere (i.e., Nasir & Cooks, 2009) because, as conceptualized, inbound and peripheral identity trajectories are specific to particular communities of practice. And while we are interested in the specific kinds of identity work that girls do in science, we have noted that their identity work powerfully crosses borders and merges practices from different communities in the effort to build an identity in science that is meaningful to them across communities. Certain forms of identity work in the moment—like leveraging dance in science class—may or may not be sanctioned in that particular space and may involve decisions that girls may make to resist becoming part of a community of practice, even when it might be science specific. Identity trajectory shifts, however, account for this movement and for the porous boundaries among figured worlds that significantly matter in how girls work toward productive science identities.

Because we wanted to understand the nature of the shifts *and* the mechanisms that supported them, Chantelle and Diane are interesting cases to explore. Diane, who initially projected a relatively strong science identity, over time and space became less interested in science and participated less frequently in class and in science club. Chantelle, who initially was not interested in science and passively participated in activities, began to think of herself as a science expert, became viewed by others as a science leader, and volunteered actively in science class.

In our broader study, and reflected in these two cases, we note two mechanisms for shifts in identity trajectories: (a) layering new meanings of selves and science with the reconfiguration of figured worlds and (b) responding to closed and inflexible structures that do not align with students' practice. We explain both mechanisms in the following using the cases of Chantelle and Diane.

Chantelle: Layering New Meanings of Self(s) in Science Along With Ongoing Reconfiguration of Figured Worlds

The case of Chantelle demonstrates that the shifts in one's identity trajectories appear along with shifts in the nature of figured worlds (including norms, roles of participants, and accessible resources) as the result of ongoing social negotiation that reflexively involves both the girls' identity work and the figured world itself. It is important to note that shifts in figured worlds appear to facilitate or constrain girls' science identity work as they move forward in space and time. A figured world that may have previously positioned a girl as a non–science person can be perturbed in ways that might further facilitate her growth. We refer to this reflexive dynamic as

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ongoing "pushes and pulls" between self and figured worlds as a girl engages in an activity system.

For example, in Chantelle's case, we noted a series of critical events that contributed substantively to her science identity trajectory: making the movie, the school workshop, teaching a lesson, and being the science expert in the lesson on energy transformations. All but the first event occurred in the formal school setting but brought together her work in the afterschool club as central to the school event. The blending resulted in creating hybrid spaces, which expanded the set of legitimized resources and constructions of the science student that were sanctioned in Chantelle's school science class. The events perturbed the system(s) for her. Bringing her afterschool science self into school and having her teachers and her peers view her as expert changed that figured world. It changed, at least for the moment, what it meant to be a good student, too. It introduced new resources for others to view Chantelle. Her identity trajectory moved and shifted *with the shifts in the system*. Chantelle's home figured world was also transformed, momentarily, when she took the lead to replace her grandparents' light bulbs. Her regular status as the "young grandchild"—who conceivably lacked authority in a family hierarchy—was elevated to that of "science expert" when her grandmother hushed her questioning grandfather by explicitly stating that Chantelle was "doing work" and had a valid reason for changing their light bulbs. The case of Chantelle demonstrates that authoring identity trajectories involves ongoing reconfiguration of figured worlds, especially when a girl authors novel identities. Girls' identity trajectories can be understood by how a girl views herself and the changing possibilities for others to be able to view her in a re-created figured world.

Diane: Closed and Inflexible Structures That Do Not Align With Own Cultural Practice

Diane initially projected a strong science identity, but her interest and participation waned as she traversed figured worlds over time and space between her seventh- and eighth-grade years. Different from Chantelle, who had opportunities for authoring new identities in an "expanded sphere of influence" created by merging different school and afterschool, Diane had to respond to the relatively small and inflexible structures that provided limited resources for her identity work.

Whereas the two figured worlds that were foregrounded for Chantelle's identity work had distinctively different activity systems, in the case of Diane, both science classroom and science lunch club had relatively similar activity systems. The science lunch club was led by Mrs. D., the seventh-grade science teacher, and it took place in her science classroom during lunch time. Mrs. D. selected activities that seemed to be interesting for the girls and/or were feasible with her limited resources, such as planting seeds in

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pots, adding Mentos to soft drinks, and discussing the reading on butterfly life cycle during their butterfly project in science lessons. Although Mrs. D. tried to create different rules of participation within the two spaces (i.e., getting the floor without the teacher's permission during science club), the girls tended to work as they worked in their science lessons. They still saw Mrs. D. as their school science teacher and Mrs. D. still saw the girls in similar ways in terms of who was good at science and who was a good student or not. The racialized peer groups and the social interaction among students did not support Diane's participation in science lunch club, as reflected in the eventual domination of the club by White middle-class girls. Unfortunately, Diane did not have other opportunities to be recognized in a different way in any science-related space. The structure of activities actually worked against Diane's identity work given that Diane's symbolic identity artifacts (e.g., winning the rocket project) were not recognized, her practices of doing science to figure things out were not legitimatized, and Diane could not carry her interests and talents in reading and writing to this figured world. Diane's shifts of her identity trajectories were gradual and slow in nature because these shifts were associated with her responses to the structure that was operated with hidden but legitimatized power dynamics. In her school science classroom where the texts provided by the teacher and the cultural practice of mainstream science possess authority and power, her struggle to find meaning within work produced negative recognition and continuously jeopardized her ability to meet the expectations of school science. Her identities within science in her eighth-grade year—"I am not good at science," "I am a bad student"—reflected the impact of her identity work on her future sense of self in science.

In short, girls' identity work in science, when viewed over time and space, reveals multiple and conflicting identity trajectories that are responsive to and defiant of the figured worlds in which they participate. Although identity trajectories are shifted as the result of the reflexive dynamics of ongoing "pushes and pulls" between self and figured worlds, for young middle school girls from nondominant backgrounds like Chantelle and Diane, who are in the lower hierarchy in power dynamics, the power of "pull" from the figured worlds can easily shift their trajectories by overpowering the "push" from the self.

Conclusions and Implications

This study explored the kinds of identity work that girls from nondominant backgrounds do as they author identities with and in science and how such work takes place and transforms across the middle school years. Using the cases of Diane and Chantelle as a guide, we argue that girls from nondominant backgrounds view their possible future selves as involved in science when their identity work is carefully recognized and scaffolded as

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demonstrated in Chantelle's case. The identity trajectories that girls author over time are a reflection of the opportunities they have had to participate in and with science, the extent to which girls are able to construct hybridity between their in school science experience and their out of school experiences (and how those actions are legitimized by others), and how the nature of the opportunities afforded or constrained greater movement in science.

According to the 2011 National Assessment of Educational Progress (NAEP) reports, eighth-grade students from all demographics who report doing science-related activities that are not for school score higher on the national science assessments, although boys, White students, higher income students, and students from private schools score higher on these assessments regardless of out of school experiences (NCES, 2011). Given this finding and what we have learned from our study, it seems imperative that girls' out-of-school experiences are critical in shaping their ongoing engagement in science and in helping to level the playing field. Further, as our study suggests, when the outcomes of out-of-school experiences—knowledge, practices, identity work—are taken up productively, there may be greater opportunities for girls from nondominant backgrounds to consider a future in science, or at least consider themselves as one who can do science.

Additionally, we find promise in the Next Generation of Science Standard's (National Research Council, 2012) focus on fostering deeper understanding and application of content through students' direct engagement in the practices of science. Diane would certainly be much better served in a classroom that supported her desire to engage in meaningful inquiry in science. That is, classrooms that allow adequate time to test out ideas, to think through problems, and to work on building evidence-based claims are more likely to support a student like Diane than a classroom focused more intently on content acquisition.

However, we worry that without explicit attention to the ongoing identity work that happens *as a part of* practice development, the power of these reforms may be lost on students like Diane. Diane's engagement with science took a form that is likely to be supported, in part, by a more coherent focus on deeper understanding and application through science practices. But her ongoing engagement in school science was also framed through how she understood her ability to do science, the recognition work that others granted her for her abilities, and the spaces she had to feel safe and free to be an African American girl who liked science. These concerns speak to real and symbolic hierarchies made manifest in the local practices of the classroom (e.g., Will a focus on direct engagement in science practices ensure that Diane's efforts are legitimized by others?) and in the broader institutional practices of schooling (e.g., What institutional practices might create spaces for it to be safe for African American girls to excel in science?).

Diane's case poses a challenging question: In the midst of current science education reforms that focus on curriculum and content, how can

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institutional histories be perturbed enough to create both the spaces and the flexibility for students like Diane to build relationships and engage in activities supportive of their interest in science? While Diane's seventh-grade teacher was thoughtful and caring and worked hard to incorporate student interest, in the end this was not enough. Diane's engagement with science was hidden by the institutional narrative regarding the good science student (finishing work quickly and efficiently, often with high grades) and further laminated by racialized power dynamics that forced choices between friendship and science.

Indeed, classrooms offer a range of figured worlds in which girls like Diane and Chantelle author themselves with and against historical and current narratives of what it means to be scientific. With these stories in mind, we suggest that school leaders and teachers develop an awareness of how the norms and routines of life in their schools and classrooms position youth in particular ways. School leaders must support teachers in working with students to recognize the moments that youth seek to productively perturb routines and norms that limit positive science identity development. Chantelle's identity work was urged on by her school's leaders. They helped to construct a safe space in school for Chantelle to try out the kinds of identity work she had engaged in afterschool and at home. This lamination of spaces—of school with afterschool and home—created moments of identity work that repositioned Chantelle, her teachers, and her peers vis-à-vis science and each other. New constructions of what it meant to be an expert were sanctioned and held up as examples of the school's mission.

We want to be cautious, however, about the simple combination of experiences. As seen in the case of Chantelle, the overlapping of formative spaces that powerfully impact the process of authoring science identities can lead to a refigured world with expanded resources and more flexible norms and rules, including what it means to be a good science student. However, they can also lead to the reinforcement of norms and expectations, as we saw with Diane. The questions like "who can be recognized as a good science students in a newly created space, and why" may be useful to evaluate the potential impacts of combinations of experiences.

Some may argue that attention to science identity and supporting hybridity between school and out of school experiences simply adds one more task for school leaders and teachers at a time when administration, teachers, and students are already inundated from all directions with various imperatives. We argue that without attention to how girls from nondominant backgrounds engage in identity work and the implementation of schoolwide efforts that support girls in challenging the traditional narrative of what it means to be a good science student and who counts as an expert, any efforts to "level the playing field" will not fully be met.

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Notes

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[1]The Light Bulb Audit video can be viewed at: http://streaming.msu.edu/storemedia/download/acb/GETCity/YEAR_4/Pleasant-View-Light-Bulb-5.mov.

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