

## Becoming (less) scientific: A longitudinal study of students' identity work from elementary to middle school science

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### **Abstract:**

Students' declining science interest in middle school is often attributed to psychological factors like shifts of motivational values, decrease in self-efficacy, or doubts about the utility of schooling in general. This paper adds to accounts of the middle school science problem through an ethnographic, longitudinal case study of three diverse students' identity work from fourth- to sixth-grade school science. Classroom observations and interviews are used as primary data sources to examine: (1) the cultural and structural aspects of the fourth- and sixth-grade classrooms, including the celebrated subject positions, that enabled and constrained students' identity work as science learners; (2) the nature of students' identity work, including their positioning related to the celebrated subject positions within and across fourth- and sixth-grade science; and (3) the ways race, class, and gender figured into students' identity work and positioning. In fourth-grade, all experienced excellent science pedagogy and performed themselves as scientifically competent and engaged learners who recognized themselves and got recognized by others as scientific. By sixth-grade, their identity work in school science became dramatically less scientific. Celebrated subject positions did not demand scientific thinking or robust engagement in scientific practices and were heavily mediated by race, class, and gender. Our results highlight three insights related to the middle school problem: (1) when students' social identity work was leveraged in service of robust science learning, their affiliation increased; (2) academic success in school science did not equate to affiliation or deep engagement with science; and (3) race, class, and gender figured into students' successes in, threats to, and identity work related to becoming scientific. We end the article by providing a framework and questions that teachers, teacher educators, and researchers might use to design and evaluate the equity of science education learning spaces.

**Keywords:** identity | longitudinal study | ethnography | equity | figured worlds | middle school

## Article:

Early adolescence, when developmental and physiological changes occur, has been commonly noted as a “critical” period for students' academic trajectories. In the 1980s, a strand of research examined the ways puberty and maturation caused individuals to become less interested in schooling (Simmons & Blyth, 1987; Simmons, Burgeson, Carlton-Ford, & Blyth, 1987). Later studies (Lord, Eccles, & McCarthy, 1994) showed that puberty was not a significant cause of middle school children's declining school interest, and research shifted to examine students' goal orientations in relation to task demands (Schunk & Pajares, 2002), relationships between motivation and choice (Eccles, 2008), and self-efficacy (Eccles & Wigfield, 2002). Research indicates that students feel a shift in motivational values for schooling as they transition from elementary to middle school, with a greater emphasis in middle school on extrinsic motivators, a greater sense of unattainability of goals by students, and fewer feelings of utility towards school topics (Eccles, Lord, Roeser, Barber, & Jozefowicz, 1997).

The transition from elementary to middle school also presents serious challenges to students' continued *science* interest, motivation, and engagement (Archer et al., 2010; Vedder-Weiss & Fortus, 2011, 2012). Explanations for declines vary, but we are most compelled by literature that takes into account connections between motivational factors (such as engagement, interest, and goal orientations) and students' social contexts, such as school culture (Vedder-Weiss & Fortus, 2011, 2012), classroom pedagogy (Meece, Herman, & McCombs, 2003), peer influences (DeWitt, Archer, & Osborne, 2013; Simpson & Oliver, 1990) and home environments (Vedder-Weiss & Fortus, 2011). Though these studies focus on different aspects of students' social contexts and though there are few science-specific studies that examine these connections, the literature that exists is in unequivocal agreement that environment matters to students' sustained or declining science interests and motivation in early adolescence.

This literature sets the stage for additional studies to examine the relationships between social context and students' science trajectories. Our study provides some new insights about the middle school science problem. We apply ethnographic and social practice theory lenses to understand the school science trajectories of three youth from fourth- to sixth-grade. These lenses allow us to extend previous literature by: (1) broadening the consideration of contexts that shape students' science trajectories beyond the classroom and school to also consider participants' interactions with cultural, historical, and social structures; (2) examining *implicit*, cultural aspects of their science learning experiences with extensive classroom observations versus relying solely on self-report data; and (3) examining the different identity work of three learners who all experienced the same school science over 3 years and, in fourth-grade, were all interested and academically capable of succeeding in science.

We also situate this study amidst identity studies literature with our focus on individuals' agency and multi-level structures that enable and constrain agency (Archer et al., 2012; Elmesky, 2011; Jackson & Seiler, 2013; Kane, 2012; Seiler, 2013; Tan, Calabrese Barton, Kang, &

O'Neill, 2013; Wood, Erichson, & Anicha, 2013). If students claim to dislike science in middle school after loving it in elementary school, we must probe more deeply into the cultural (implicit) meanings of science in their school science experiences. Who are students obligated to be in school science? What does it mean to perform oneself scientifically? How interesting and achievable are those scientific performances for all students? Who do these celebrated performances privilege and marginalize? How do individuals perform themselves within and against these implicit norms? What resources do they draw on to construct meanings of their experiences and themselves? These questions highlight the relevance of identity work for understanding students' science trajectories.

This paper reports on a 3-year, longitudinal case study of three ethnically, racially, socioeconomically, and linguistically diverse students in school science. The study begins in their fourth-grade year, where they all experienced excellent science pedagogy with the same teacher and where they all performed themselves as scientifically competent and engaged learners who recognized themselves and got recognized by others as scientific. Unfortunately, the story is not entirely optimistic as, over the next 2 years, all students' identity work in school science became less scientific. Sixth-grade, dominated by low-level, minimally demanding tasks and emphasizing canonical science, prompted resistance and/or compliance which resulted in problematic science trajectories for all three students. Their stories demonstrate that students who are capable of and interested in performing themselves scientifically in one setting cannot easily become scientific in settings that offer them limited subject positions and where they are not held accountable to perform themselves scientifically. This seemingly commonsense finding, connecting students' enacted identity performances to the nature of the school science settings, is actually quite significant because it demonstrates the ongoing disciplining of students (Foucault, 1977). That is, students' identity work may involve different performances and take on different meanings depending on the norms, practices, values, and demands of the setting and the enabling and constraining aspects of history and larger social structures.

## **Conceptual Framework**

### **Grade-Level Science as the Interweaving of Various Figured Worlds**

Social practice theory (Holland, Lachicotte, Skinner, & Cain, 1998) provides the concept of “figured worlds” that became a prominent lens through which we viewed our research problem. Figured worlds are sociohistoric, collective “realm[s] of interpretation” (p. 52) that provide the “contexts of meaning for actions, cultural productions, performances, disputes, for the understandings that people come to make of themselves, and for the capabilities that people develop to direct their own behavior in these worlds” (p. 60). The concept of figured worlds allowed us to examine the structure agency dialectic involved in identity work. “Figured worlds represent the ‘rules,’ ‘guidelines,’ or social forces that influence (but do not completely dictate) the ways people speak, behave and ‘practice’ within social spaces” (Hatt, 2007, pp. 149–150).

Holland et al. (1998) provide examples of figured worlds that clarify how these “as-if realms” shape normative behaviors, interactions, and beliefs in very real ways. For example, they describe the “figured world of romance” of female undergraduates and their socially constructed romantic world (see also Holland & Eisenhart, 1990). This figured world included a high value for romantic encounters and relationships with those of the opposite sex. The women constructed attractiveness in terms of its validation by men and developed a set of gendered vocabulary to describe those involved in romance (lovers, hunks, dumb broads), the acts associated with the world of romance (flirting, dumping, loving, having sex with) and the forces involved (attraction, love) (p. 102). They argue, “[T]he figured world of romance acquired motivating force as the women developed mastery of it, and their mastery, in turn, depended upon their development of a concept of themselves as actors in the world of romance” (p. 99).

While the above example highlights the structural side of figured worlds, Hatt (2007) provides an example of the ways individuals' agency plays into re-defining the rules of the game. Hatt described how a group of typically marginalized students re-figured the “world of smartness” as presented to them in school to accommodate a new figuration of “book smarts vs. street smarts.” Book smarts stood for the kind of book knowledge and attention to academic pursuits valued in school, gained by studying and working hard in school, and “street smarts” described the necessary know-how to navigate the poverty, street culture, and students' everyday realities gained from experience. The students placed a higher value on street smarts as relevant to their lives and maligned “book smarts” as irrelevant. Thus, they actively disaffiliated from academic pursuits, with negative ramifications for their positioning within school.

Romance and smartness, as figured worlds, are fairly stable (though not fixed) “shared, idealized realms involving identifiable character types and actions” that have historical persistence (Michael, Andrade, & Bartlett, 2007, p. 168). In our study, we considered the various historically enduring figured worlds that were relevant in the different science classrooms, in different configurations, and to different degrees. Similarly to Tan et al. (2013), we considered the *science classroom as the interweaving of various figured worlds*. However, Tan et al. defined the classroom's figured worlds as different configurations of classroom activity (e.g., whole group lecture, small group activities), while we used a more macro-level timescale (Jackson & Seiler, 2013) to identify how different figured worlds organized classroom practices, norms, and subjectivities to appear natural or thinkable (Archer et al., 2012).

We made the assumption that each classroom celebrates certain kinds of scientific and social performances and marginalizes others, making some macro-level figured worlds more relevant than others. For example, the *figured world of traditional schooling* is prominent in a classroom emphasizing knowledge, memorization, bookwork, and sorting of students based on performances (Kane, 2012). Viewed this way, there were various macro-level figured worlds that influenced what counted as science and who got counted as a good science student in the different science classrooms in our study (e.g., the figured worlds of reform-based science and traditional school science, described in the cases below).

Classrooms also leveraged various out-of-school figured worlds. Labeling these “non-school” figured worlds was a bit problematic as our labels were culturally laden. For example, we noted the norms and practices that emphasized togetherness, empathy, collaboration, and nurturing as indicative of a *figured world of family*. While we recognize that this is a culturally biased view of family, we also note that family, with recurrent and powerful images of togetherness and belonging (McCarthy, 2012) “is a stubbornly pervasive point of reference in everyday language” (Gilding, 2010, p. 774) and represents, like the figured worlds construct, an “idealized realm” (Michael et al., 2007). Similarly, our label of the figured world of childhood, with associated youth genres of “kidspeak” and kids' humor, curiosity, excitement, innocence, and ingenuity reflects a widely circulating, available, idealized cultural narrative of what it means to be child-like. Conceptualizing the classroom as the interweaving of figured worlds became a powerful metaphor for understanding the enabling and constraining aspects of the classrooms. A classroom rich and thick with threads from different (empowering and relevant) figured worlds, one could infer, is a place where more students have greater opportunities to engage meaningfully in and to develop identities in science (Maskiewicz & Winters, 2012).

### **Identity, Positioning, and Celebrated Subject Positions**

Jackson and Seiler (2013), following Holland et al. (1998), explain that “figured worlds rely on cultural models” (p. 828) that are meaning-making tools for participants. The classroom's loom of figured worlds and their associated norms and practices celebrate certain subject positions and marginalize others. Our conceptualization of the celebrated subject position, or a “cultural model” of who counted as a legitimate scientific person and what counted as celebrated scientific performances, became a prominent part of our analysis. Becoming “scientific” meant positioning oneself (deliberately or not) and/or getting positioned as a “good” science participant and therefore aligned with, being able to fit into and/or see oneself inhabiting the classroom's celebrated subject positions. This was easier for some students than others. When things went awry for students, we found it illuminating to understand their difficulties in light of the breadth of the available subject positions, their difficulties accessing the practices privileged within celebrated subject positions, and the sometimes problematic recognition work related to the raced, classed, and/or gendered nature of celebrated subject positions. Our analysis of celebrated subject positions in classrooms brings to the fore the notion that people's positions matter (Urrieta, 2007). Our conceptions of identity highlight the work and the dynamics of power that are involved in producing people and in becoming a certain kind of person. All of this local production gets intertwined with, shapes and gets shaped by larger social structures like race, class, and gender (Archer et al., 2010; Elmesky, 2011; Kane, 2012; Seiler, 2013).

### **Studying Identity Work Over Time**

Since Brickhouse, Lowery, and Schultz's (2000) pioneering study of four African-American girls in science across seventh and eighth grades, there have not been many qualitative, longitudinal studies of identity work, though some work has been published within the last few years

(Calabrese Barton et al., 2013; Jackson & Seiler, 2013; Johnson, Brown, Carlone, & Cuevas, 2011; Krogh & Andersen, 2013; Packard & Nguyen, 2003; Tan et al., 2013). At the time of our analysis, we were charting relatively new territory, conceptually and methodologically. Some difficulties, also noted by other researchers, were: (1) avoiding simplistic reification of a students' identity work; (2) understanding what aspects of identity “thicken” (Wortham, 2006) or “become stabilized” (Calabrese Barton et al., 2013) over time; and (3) avoiding artificial linearity in understanding trajectories. These recently published longitudinal, qualitative studies of identity work share commitments to: (1) emphasizing the structure/agency dialectic and multi-temporal aspects of identity work by using the figured world construct; (2) avoiding identity as a reified, static construct; and (3) toggling between timescales to understand how resources cultivated in one setting might be leveraged in another setting in support of cumulative or disruptive identity work. There are, however, differences between the studies' analytic approaches. We provide a brief summary of two recent studies to demonstrate some conceptual similarities and differences.

Calabrese Barton et al. (2013), as part of a larger study of 36 girls' identity work within and out-of-school settings, studied two girls' identity work from sixth to eighth grades. They focused on three to four critical events in each grade-level that appeared to provide resources for girls' science-related identity work in other spaces and future events. Their approach privileged the *event*, the resources cultivated and leveraged through participation in the event, girls' roles during the event, and the identity artifacts the event produced that became stabilized or transformed in future events. Further, they play with the temporal nature of identity work by emphasizing the ways one's history becomes embodied in one's current and future narrations and performances of self. They emphasize identity work over time as “cumulative” because of the ways identity work and artifacts in one setting become salient for future identity work and “contentious” because of the “structures of power, privilege, and oppression” (p. 68) in which it occurs. Like our study, their work emphasized that “the identity trajectories that girls author over time are a reflection of the opportunities they have had to participate in and with science ... and how the nature of the opportunities afforded or constrained greater movement in science” (p. 36).

Jackson and Seiler (2013) studied the science identity trajectories of latecomers to science during their first year in a college science program and the ways those trajectories were shaped by the cultural models and available resources in the program. They use the phrase “identity trajectory” to promote an understanding of identification as “motion in relation to science at any moment, where stronger/weaker identification with science is analogous to faster/slower motion towards science” (p. 830). Their identity trajectory model does not presuppose linearity; it recognizes the shifts and transformations that may occur as participants encounter new contexts. However, they account for directionality with the concept of “momentum,” a “buildup of resources that creates a patterning or thickening of identity” (p. 831) over time. This conceptualization helps explain how and why, over time, “it becomes increasingly easier or harder to identify with science” (p. 831). They depicted structural resources, like dominant cultural models in the science program

they studied, as “forces” on individuals' trajectories that accelerated “them towards or away from science” (p. 831). Their methodological approach privileged the *participants' narratives* in reflective writing and interviews, which made visible students' ongoing ideas about themselves and the cultural models that shaped their ideas.

Both of the above studies used different methodological approaches to study identity work over time. Our study highlights a third approach. Like the studies above, we began with the assumption that there would be “some consistencies and at least some directionality in the ways [participants] author themselves” (Johnson et al., 2011, p. 345), despite the different learning contexts in which they found themselves. We honed in on three consistent social identity performances—the ways that students consistently performed and/or described themselves during science lessons, interviews, and across each school year (e.g., being a pleaser, a “good student,” a defender of the underdog). Then, we examined how the *meanings of their consistent social identity work* shifted or remained consistent in the different cultural contexts of each year of school science. We focused attention on how the ascribed meanings of their identity work positioned them in relation to each classroom's celebrated subject positions and to science. We do not claim, nor did we try, to capture all aspects of students' identity work.

Similar to Calabrese Barton et al. (2013) and Jackson and Seiler (2013), we toggled between analytic grain sizes to make sense of students' identity work and positioning. We moved back and forth from classroom norms and practices (local structure) to figured worlds that informed, sustained, and were reproduced by those practices (global structures) and between students' identity work (agency) and its meaning in relation to the celebrated subject positions (local structure) and social structures of race, class, and gender (global structures). Doing so allowed us to peek into the black box of school science to understand some implicit processes that likely contributed to students' problematic science trajectories.

Below, we describe the figured worlds and celebrated subject positions in relation to students' consistent identity work in each grade-level. Our research questions were: (1) What is the nature of the available and celebrated subject position(s) in each year of school science? (2) How did the students' consistent identity work in each year of school science position them in relation to the celebrated subject position(s) in each year of school science? We critically analyze the findings by describing how race, class, and gender figured into students' positioning and identity work in their science classes and in relation to science.

## **Methods**

### **Study Participants and Study Context**

This study is part of a larger, longitudinal study that focused on the short- and long-term identity affordances of excellent elementary science teaching for a diverse population of students (NSF #REC0546078). The case study students' fourth-grade teacher, Ms. Wolfe, was recommended by administrators, parents, and/or fellow teachers as an “excellent science teacher.” Elsewhere

(Carlone, Haun-Frank, & Webb, 2011), we describe the culture of Ms. Wolfe's classroom. All case study students had the same fifth- and sixth-grade science teachers, and the study here follows them through sixth-grade science. We chose three case study students who, at the end of fourth-grade, labeled themselves and/or were labeled by others as the one of the smartest science students in the class and who all excelled academically. The students' elementary and middle schools were located near a large University where there was wide-ranging socioeconomic diversity, low teacher turnover rates, and high student achievement.

## **Data Collection and Analysis**

### **Classroom Observations**

Consistent with an ethnographic approach, we privileged classroom observation data in our analysis, but we collected multiple forms of data across 3 years of school science. All data were collected by Carlone and/or members of her research team,<sup>1</sup> all but one of whom were White and all but one of whom were women. Our perspectives as mostly White women were necessarily partial, so we sought feedback from colleagues with diverse professional and personal backgrounds and with our participants as we began to make sense of the data (see Acknowledgments). Due to space constraints, we limit the reporting of our analysis to the fourth- and sixth-grade classrooms since they represent the most dramatic shifts in students' identity work. We conducted 38 observations of Ms. Wolfe's fourth-grade classroom in 2007–2008 and 32 observations of Mr. Campbell's sixth-grade classroom in 2009–2010. We videorecorded each observation, took detailed fieldnotes (Spradley, 1980), and wrote up contact summary sheets (Miles & Huberman, 1984). We catalogued all videos and fieldnotes. The first and second authors, with initial help from a larger research team, closely analyzed and re-analyzed all videorecordings that featured case study students. Though multiple people from the research team collected data, we used a similar observation protocol across 3 years.

### **Interviews**

Each student was interviewed formally, with an end-of-year semi-structured interview protocol aimed at capturing students' meanings of the classroom's scientific and social norms (Cobb, Gresalfi, & Hodge, 2009) and the ways they positioned themselves in relation to those norms ( $n = 3$  interviews/student). These interviews helped us capture their definitions of what it meant to be “smart” in science (i.e., celebrated subject positions), whom they defined as the “smart” (i.e., who fit best within celebrated subject positions and why), and how they positioned themselves in relation to the “smart” students. Further, we talked with students informally throughout the study, and those conversations, recorded as fieldnotes, became a part of the data. In fourth-grade, we held one “lunch bunch” focus group meeting with students and, in sixth-grade, we interviewed them individually mid-year, which allowed us to capture their ongoing meanings of, and affiliation with, their school science experiences. In addition to numerous informal conversations with teachers, we conducted one end-of-year interview with each teacher



to gather their perceptions about: their classroom's scientific and social norms; each student's positioning in relationship to those norms; students' family backgrounds, out-of-school interests, and engagement in other academic subjects. We interviewed parents one time during the beginning of students' sixth-grade year to supplement data generated from the children and teachers about their outside interests, social identity work, and scientific interests.

### **Student Work**

Student work provided some information about students' scientific understanding, insights (in fourth-grade journals), and performances on assessments, homework, and projects. In sixth-grade, the student work did not provide a lot of information about students' scientific understanding as nearly all of it was fill-in-the blank and/or formulaic. However, it did provide us additional evidence to ascertain the narrowness of the celebrated subject positions and students' willingness and/or ability to conform to those positions.

### **Defining the Celebrated Subject Positions**

The first research question, focused on the nature of the celebrated subject positions in each year of school science, necessitated a cultural analysis. We identified the normative scientific practices in each setting; these were the practices in which students were held accountable to be considered good participants in the setting (Carlone et al., 2011). Following Duschl and Kelly (2002), we focused on patterns of: (1) epistemic practices (e.g., ways to observe, infer, justify, evaluate, and legitimate scientific knowledge); (2) communicative practices (e.g., kinds of questions; peer-to-peer and student-to-teacher interactions); and (3) investigative practices (e.g., scientific questions; using data to generate knowledge; scientific observation, problem-solving). Throughout data analysis, we asked ourselves, “What counts as science in this setting? What counts as being a ‘good’ science participant? What are the obligations of positioning oneself as aligned with/able to fill the celebrated subject positions? What are the relevant figured worlds that shape what counts?” We paid attention to the practices and ways of acting that were celebrated, marginalized and/or condemned and the historical and cultural narratives (figured worlds) that might have been mobilized in the production of the “good” science person.

We also used the card sort in end-of-year interviews to help us answer these questions. Each card included one normative practice (e.g., “sharing scientific ideas,” “talking like scientists,” “getting the right answer”). During the card sort, participants: (1) sorted the cards into piles of yes/no/maybe to indicate the importance of that practice for being considered a “good” science student in their class; (2) discussed the meaning of that practice for their science class and provided examples of that practice; (3) chose the three most important practices for succeeding in science class; and (4) chose the three most important practices that would be a part of their “ideal” science class (see Carlone, 2012 for a full description of the card sort method).

### **Analyzing Individual Students' Identity Work**

Our second research question focused, in part, on the nature of the students' consistent identity work within and across fourth- and sixth-grade school science. We examined the ways they regularly performed and described themselves, and the ways others described and recognized them. Certain codes were especially illuminating. We paid attention to instances where issues of *power* were brought to the fore and examined the nature of and responses to *students' bids for recognition* (e.g., when they did so, for what reasons, from whom they bid). Doing so enabled us to draw inferences about what they deemed important enough to get recognition for, whose recognition mattered to them, and the ways their teachers and peers responded to them. Instances of students *holding the floor* (e.g., speaking or acting while holding others' attention for extended periods of time) were also relevant to understanding their identity work and positioning. Finally, instances of *conflict* brought to the fore the students' struggles and frustrations in ways that highlighted discrepancies between the settings' celebrated subject positions and students' preferred identity work.

### **Characterizing Identity Work Over Time**

We iteratively moved between the inductive work of coding to create emerging “storylines” about each student and then deductively returning to the data looking for confirming and disconfirming evidence of the emerging storyline. As described above in the conceptual framework, we looked for patterns in the ways students performed themselves, socially and academically, got recognized by others, and made meaning of their school science engagement. After a lot of iterative analysis and discussion among the authors, we identified three identity performances (“identities-in-practice”) that were consistent with their narratives of self (“narrated identities”) across time (Tan et al., 2013). As one example, William could be characterized as conscientious in fourth-grade. We asked ourselves about the ways he was or was not conscientious in fifth- and sixth-grades and questioned the focus and meanings of William's conscientiousness in these new settings.

### **Intersections of Race, Class, and Gender**

In the discussion, we interpreted the results to show how ways race, class, and gender shaped students' positioning. In particular, we examined the relevance of race, class, and gender for positioning oneself as aligned with celebrated subject positions in each classroom, focusing on how, or to what degree, those spaces ideologically privileged status quo, mainstream, dominant ideas about what it meant to be a “good” student (Fordham, 1993). Given what we knew about students' consistent identity work, was it equally possible for all students to occupy celebrated subject positions? We drew on inductive insights from the data and deductive insights from social practice theory and, in particular, the notion of positioning (Holland et al., 1998). Everyday “practices always positioned the participants situationally, relative to one another” (p. 133).

### **Results**

We organized the results to demonstrate the iterative nature of structure (figured worlds, celebrated subject positions) and agency (students' identity work in relation to those structures) in youths' science learning pathways. We provide an introduction to each case study participant to situate later descriptions of their consistent identity work from fourth- to sixth-grade. Then, we describe each year of school science separately, illustrating relevant figured worlds that shaped the celebrated subject positions and the consequences of those structures for the meanings of students' consistent identity work and their positioning in relation to science.

## **Introduction to the Youth**

### **William**

William's family emigrated from El Salvador before he started kindergarten, and he lived with his mother, father, and younger brother and sister. His parents spoke very little English; Spanish was their primary language at home. His family owned a small, one-story home, modestly furnished and sparsely decorated. His mother described him as intelligent, highly independent, and humble, explaining that he “always worries about his studies. Sometimes I'll say, ‘William, you have to eat!’ And he'll say, ‘No, I have to do my homework first!’ ” (9/15/09). She also described him as naturally curious and a good friend—descriptions that supported our own observations of him as someone who liked considering scientific ideas and who was noted by classmates across the years as someone who “works really well” with partners. His fifth-grade teacher said, “He thrives on adult compliments and peer compliments,” “wants to do everything right and get everything right” (6/3/09). His desire to do the right thing made him a “meticulous,” but “cautious science student” who liked “known-answer questions” so that he did not necessarily “push the curriculum to the what-if stage” (Teacher interview, 6/3/09).

As a member of the dual-language cohort from kindergarten to fifth-grade, William got along well with his classmates. His proficiency in both Spanish and English made him a valuable peer for native and non-native Spanish speakers. He was, perhaps, a more “serious” student than some of his friends and, according to his fifth-grade teacher and “more of a child” than some of his Latino male friends, both physically and socially (6/3/09). In 3 years of observation, we never saw him get chastised by a teacher for his behavior, which was unusual for all of his peers (girls and boys), most of whom got chastised at least occasionally. Across 3 years of school science, William *consistently* performed himself as: conscientious, sometimes to the point of worrying about doing the right thing, a pleaser, and a good student (i.e., someone who “does school” well). See Supporting Information Table 1 for a summary of William's identity work and positioning over time.

### **Amy**

Amy came from a socioeconomically privileged Caucasian family and lived with her mother, father, and two brothers. She spent summers visiting her family's beach house, traveling nationally and internationally for family vacations and to competition jump-rope tournaments,

and attending the occasional camp. Her parents enrolled her in the dual-language cohort in kindergarten, providing her with a socioeconomically, racially, and ethnically diverse group of friends through elementary school. She was a consistent “A” student who sought and thrived on positive recognition from teachers and worked hard to meet, and often exceed, expectations. Identified as an academically/intellectually gifted (AIG) student, her teachers described her as someone who “loves learning” (6/3/09). At home, Amy enjoyed hands-on, creative and outdoorsy kinds of things like playing in the woods and creek behind their house, craft projects, helping her father with home improvement projects, and cooking (Parent interview, 10/7/09).

At a time when gender performances were becoming more pronounced for many of her peers, Amy distanced herself from prototypical gender performances, dressing in t-shirts and jeans or shorts, without make-up or lots of jewelry from fourth- through sixth-grades. Her fifth-grade teacher said, “She's kind of a tomboy and when the girls are off talking about the boys she's with the boys playing tag and whatever. She can't be bothered with that nonsense” (6/3/09). The neighborhood boys were her best playmates. “She has no problem shooting hoops [with the boys] even though she's not good at it” (Parent interview, 10/7/09).

From fourth- to sixth-grade school science, Amy *consistently performed herself* as: pleaser (of peers and teacher), problem-solver, and an adaptable good student. We describe her as an “adaptable good student” in comparison with William's “good student” identity work because for Amy, this identity work was fairly easy and for William, the work was a little more difficult and worrisome. In every class, she met or exceeded teachers' expectations and was consistently recognized by peers as one of the top science students in end-of-year interviews. Supporting Information Table 2 summarizes her identity work and positioning over time.

## **Aaliyah**

Aaliyah, an African-American girl, lived with her mother, who worked in human resources at a nearby university. An avid reader—by sixth-grade, she read at least “an hour to an hour and a half every day” (Parent interview, 10/8/09)—she had wide-ranging interests. She liked to be active, mentioning interests in tennis, kickball, swimming, volleyball, and soccer. In addition, she loved animals, coming up with entrepreneurial ways to make money (e.g., making and selling jewelry), cooking, singing, and dancing. She unabashedly said that “lots of people say I'm such a drama queen” (5/28/08), and she had an interest in being an actor someday. She also mentioned interests in being a veterinarian, chef, lawyer, and singer.

Aaliyah and her mom faced a serious house fire the end of fourth-grade, which she mentioned affecting her concentration in school: “Ever since the fire, I haven't been able to think straight” (5/28/08). Further, she had a difficult relationship with her father. This relationship loomed large in fifth- and sixth-grade interviews with her, her mother, and her teachers. She noted him as one of the “big problems” in her life: “My dad. That's one [problem]. Had to solve how to get him out of my life and yet he's still here” (10/8/09).

Aaliyah's teachers described her as unusually bright. By sixth-grade, she was identified as an AIG student. Her fifth-grade teacher, who did not believe in “gifted ed” labels said, “It's amazing to see ... she's actually one of the truly gifted children” (6/3/09). In addition, Aaliyah was unusually socially savvy and straightforwardly named and challenged practices and/or behaviors she found unjust: “She has a lot of social wherewithal” (Teacher interview, 6/3/09). Though her dual-language cohort in elementary school was diverse, she was the only African-American girl (and one of two African-American students). In sixth-grade, she was also in the ethnic and racial minority, as one of three African-American girls (out of four African-American students total) in her science class. Her mother described her as popular amongst her peers, “but she's not the typical popular girl ... she always watches out for the underdog ... takes everyone in and makes them feel special” (10/8/09). Aaliyah went through fairly drastic changes with her identity performances and positioning from fourth- to sixth-grades. Even so, we saw from her the *consistent identity work* of: claiming (physical) space, claiming voice, and nurturing and standing up for the underdog. On Supporting Information Table 3, we summarize her identity work and positioning.

#### **Fourth-Grade Science: Figured Worlds and the Celebrated Subject Positions**

Ms. Wolfe's classroom invoked the *figured world of reform-based school science*. Scientific knowledge was generative and socially constructed. Students recognized creativity and curiosity as criteria for performing oneself as a “smart science student.” For instance, 10 of the 18 students interviewed said that being smart in her science class meant being curious and asking good questions. One student said, “We have to think other thoughts. We have to think outside of the box.” Scientific investigation involved careful observation, question-asking, and trying out one another's ideas together; it was a collaborative endeavor. Ms. Wolfe vigilantly scaffolded and held explicit, high expectations for students to be good observers, question-askers, and groupmates. Students knew that one way to get recognized by Ms. Wolfe was to share an innovative observation. We saw many bids for recognition akin to, “Ms. Wolfe! Look what I discovered.” Her response was usually enthusiastic and often included a question or two to push their thinking further. “Why do you think this happened?” “What would happen if you tried to use two bulbs?” “Did the frog *really* jump? Or, did it move differently? Be specific.”

We also saw the relevance of the *figured world of family*, with priorities of collaboration, getting along, empathy and helping one another. A prominent social norm of the classroom was “we solve problems together”; they were held accountable for explaining their own ideas and also their groupmates' ideas. For instance, “she and the children would brainstorm ways to ‘appropriately’ work in groups, pertinent questions to ask one's partner, ... polite ways to correct a partner's mistake,” and even ways to physically position their bodies (Carlone et al., 2011, p. 472). This was a dual-language immersion classroom, with half of the instruction in Spanish and half of the instruction in English. Approximately half the students were native English speakers and half were native Spanish speakers. Thus, priorities of collaboration and empathy took on particular relevance in this setting. When instruction was in English, the native Spanish speakers

may have needed more time to articulate their answers and the reverse was true when instruction was in Spanish. It was a classroom norm to be patient with others. For example, she said, “I did not think it was inappropriate for me to say, ‘Fernando needs a little bit more time to think than you do in English. So we're just gonna chill for a second’ ” (8/13/08).

Further, Ms. Wolfe enacted a genuinely child-centered pedagogy, and we viewed this as drawing on the *figured world of childhood*. She used silly examples in class, like having one of her students serve as a model for an “organism” when they were learning how to record detailed observations of different properties of animals and their habitats (1/7/08). When introducing the idea that inventions solve problems, she used the example of a toilet (5/9/08). She delighted in their enthusiasm, creativity, and trusted them to ask questions that led to productive scientific investigation. She rarely followed the scope and sequence of the packaged, kit-based curriculum materials, but instead, let students ask questions that would lead to the next investigation.

The incorporation of these figured worlds—reform-based science, family, and childhood—into Ms. Wolfe's classroom created *broadly construed celebrated subject positions*, animated with active, engaged, curious, playful, problem-solving, collaborative, and empathetic practices and learners. The celebrated subject position, or the cultural meaning of scientific person, was someone who “share[d] scientific ideas with others, buil[t] on and question[ed] others' ideas, and contribute[d] to the class's scientific knowledge”; they were polite and “patient about and active listeners of others' ideas” (Carlone et al., 2011, p. 473).

We were struck by the multi-faceted, on-task, productive science engagement of nearly every student in the class in nearly every observation we conducted. Students were not only given accessible opportunities to perform themselves scientifically, but all were *obligated* to do so (Gresalfi, Martin, Hand, & Greeno, 2008). They were all held accountable to asking questions, making careful observations, providing evidence with their scientific explanations and inferences and, perhaps most importantly, to speaking up and claiming voice. These practices opened up the accessibility of the celebrated subject positions. On Supporting Information Table 4, we summarize the figured worlds shaping the celebrated subject positions promoted in fourth-grade.

### **Fourth-Grade Science: Students' Identity Work in Relation to Figured Worlds and Celebrated Subject Positions**

The most striking aspect of fourth-grade science was that students' identity work was an important resource leveraged to align oneself with celebrated subject positions. Being scientific, being a good class member, and being “me” were mutually reinforcing performances.

#### **William**

William's identity work as a *conscientious/worrier* was leveraged to persist, to figure out how to best to solve scientific problems and how to get students to work well together. In small groups, he would often make bids for leadership, proposing his own ideas or delegating tasks to other

students, trying to make sure that they finished the assigned task (which also overlapped with his “good student” identity work). His bilingualism made him a strong, nurturing group member for both English- and Spanish-speaking students, performances that were celebrated aspects of a classroom shaped by the figured world of family. The group often followed his leadership, an indication that they accepted his bids for recognition as a leader. In the end-of-year interview, Aaliyah nominated William as one of the “smartest science students” in the class, describing how his conscientiousness made him a good partner in science:

When he works in partners, he works really well. He's always concentrating and he doesn't get off track ... he'll explain what you need to do. And like if you're not paying attention he'll make you pay attention (Student Interview, 5/28/08).

William worked hard to make sure that he and his peers were always on-task and keeping track of important details. He sometimes worried about these details. For example, while helping to prepare a habitat for the class fiddler crabs, William suddenly gasped, concerned about adding salt to the habitat to ensure that the crabs survived and diligently worked with his peers to make sure the habitat was safe for the crabs (11/28/10).

It was characteristic of him to collaborate like this, concentrating on a problem and then asking a question or pushing his peers to think further. These performances came across as conscientiousness, sometimes bordering on worry. For example, William responded this way when a group member proposed feeding pizza to the class fiddler crabs to find out how much they eat: “We don't know what they eat. What if they eat pizza and they don't know it's pizza, and they die?!” (Video, 11/28/07). His concern prompted the entire group to do more research before choosing the type of food they would use for their experiment.

His identity work as *good student and pleaser* could have led him to focus simply on finishing tasks or getting an answer, but the figured world of reform-based science reinforced norms that led to generative thinking and scientific problem-solving. So, being a good student—that is, aligning oneself with celebrated subject positions—meant more than just being “right” or finishing tasks. Ms. Wolfe pushed him to ask scientific questions and to wonder about the “why” of his observations and findings and, since he thrived on compliments from his teacher, he strove to display his good scientific thinking. For example, one day Ms. Wolfe asked each small group to analyze the graphs they created from an induced magnetism experiment, prompting them to come up with questions that emerged from a close examination of the data. When William noted a steep downward curve on his graph, he pointed it out to Ms. Wolfe, and said, “I mean, why?!” She said excitedly, “That's my question, too, William!” (Video, 4/10/08). William beamed. Her response is an example of how she supported students' access to celebrated subject positions.

He took up this practice of being curious in small groups, too. More than once, we heard him ask his classmates to make their thinking visible, much like Ms. Wolfe did, demonstrating his desire to understand the activity rather than just finish it. For example, when Jason suggested that they

needed “more batteries and less wires” to make the bulb brighter in their circuit, William requested, “Explain” (Video, 4/28/08). Ms. Wolfe's classroom norms, drawing on the figured world of reform-based science, childhood, and family, supported William in learning to take risks and move beyond playing the safe, compliant “good student” role.

## Amy

Amy embraced risk-taking and problem-solving. The celebrated subject position was a seamless fit for the *problem-solver* identity work that came naturally to her. Peers noted her as a top student because, “Amy tries things, and if they don't work, she tries them again” (5/29/08) and another student said, “Amy is really good at figuring things out” (5/29/08). She was a generative thinker: “Amy's always thinking about different experiments to do. I mean that's all she thinks about in science” (5/28/08).

Amy consistently performed herself as an affable *pleaser* and an easy-going, positive, and energetic group member. Her bids often centered on sharing scientific observations, inferences, or questions with peers and teachers. During the introductory magnet lesson, she playfully wrapped a pipe cleaner around a pencil and picked it up with a magnet. She excitedly showed her peers, “Oh! My pencil's magnetic!” holding it high above her head so Ms. Wolfe could see it across the room. Ms. Wolfe responded, “Interesting! So fabric is magnetic?!” Amy said, “No. It's the pipe cleaner! The metal in the pipe cleaner” (4/9/08).

She was an enthusiastic and frequent volunteer of answers and questions in whole group discussions and a gentle, nurturing leader in small group work. She often could finish tasks more quickly than her peers, but she was patient with classmates. She helped get her group's activity underway (e.g., 11/28/07; 4/9/08), helped those who did not understand an activity (e.g., 11/28/07—“Laura, do you need me to help you?”), helped her group configure their data tables or graphs (11/30/07; 4/9/08; 4/18/08), made sure everyone in the group had access to the materials (4/9/08), and/or fixed problems with equipment. When the teacher complimented her on a discovery she made with induced magnetism, she credited her much quieter partner, Juan, a new student whose family recently emigrated from Mexico—“It was actually Juan's idea” (4/10/08). Ms. Wolfe complimented her: “That is kind of you to give him credit. That's the way scientists work well together.” These examples illustrate her positioning as aligned with the classroom's celebrated empathetic subject position shaped by the figured world of family.

Ms. Wolfe nurtured Amy's *adaptable good student* and *problem-solving* identity work by prompting her to think about why things were happening and providing her with “challenges” when she finished early (e.g., 4/25/08; 5/2/08). When Amy did not provide substantial scientific explanations, Ms. Wolfe propelled her to do so. During a one-on-one conference about Amy's invention ideas during the electricity/invention unit, Amy discussed her preference to create a light for the back of her scooter so that she could ride the scooter in the dark.

- Ms. Wolfe: Why [do you want work on that invention rather than your other idea]?



- Amy: Because I think it would be more fun.
- Ms. Wolfe: Ok, so besides being fun, why would you want to do the scooter one?
- Amy: Because I think I'd get—I think it'd be better. And it would work better.
- Ms. Wolfe: Ok, how do you think it would work better? Tell me about what you've done in science that would allow that one to work better.
- Amy: I'd make a circuit, with lightbulbs at the back of the scooter. And a cardboard box in the front, in between the handlebars, that has the circuit in it and a switch next to it to turn the lights on and off (5/16/08).

The discussion continued with Ms. Wolfe encouraging her to think about the science and feasibility of the design, including the numbers of bulbs, the purposes the bulbs could serve on the scooter (safety, braking signal, turning signals), and the benefits and drawbacks of the type of circuit she might create. Ms. Wolfe pushed Amy to perform herself *scientifically*, giving her new challenges, prompting her to make her scientific thinking visible, and holding her accountable to think on her own if she got stuck (5/9/08). These practices raised the bar for a pleaser like Amy, who strove to exceed classroom expectations.

### **Aaliyah**

Aaliyah enthusiastically replied, “That's a definite yes!” (5/28/08) when asked if she liked science this year. Her performance showed consistent, whole-body engagement. Aaliyah's *claims to space* were nearly always leveraged to make bids to be recognized by her teacher as a contributor to the class's scientific ideas. In class discussions, when most children were sitting on their bottoms, with legs crossed, Aaliyah was sometimes on her knees, inching higher and higher, leaning forward with her hand high in the air, making earnest and enthusiastic bids to be recognized by the teacher for scientific contributions (11/30/07; 4/10/08; 5/7/09).

Though she was not always called on because Ms. Wolfe was committed to “calling on the least talkative students” (8/3/08), Aaliyah remained a frequent volunteer in discussions. She *claimed voice* to vividly share her scientific observations. She held the floor to answer the teacher's questions and to explain her thinking. For example, when asked to share an observation about a fiddler crab investigation she, without prompting, provided evidence for her thinking:

Me and Camilo had noticed one day that I saw a female [fiddler crab] trying to eat the potato skins, but since her claws are so little, she wasn't able to rip any pieces off. And Camilo noticed that he saw the alpha male even trying to eat the potato skins and *he* couldn't even rip it with his big claw (11/30/07).

She *claimed voice* to use language descriptively and precisely. For example, when she and Julio created a chart about the animals, she recommended that he write “trapezoid” instead of “oval,”

“pale” instead of “white,” and “thin, vertical pupils” instead of “straight pupils” (12/17/07). Ms. Wolfe positioned Aaliyah as one of the intellectual leaders in class, for example, requesting that Travon ask Aaliyah for help because he was absent the day before (4/10/08) and suggesting Aaliyah help Frederico on a graphing task he struggled with (4/28/08).

Aaliyah also *claimed voice* to make fanciful connections that demonstrated emotional investment, which was a great fit for the figured world of childhood leveraged in this class and the curiosity promoted by the celebrated subject positions. She noted with joy and wonder the ways the fiddler crab's eyes looked like “aliens” (11/30/07), rejoiced with a loud, “Hallelujah!” after solving a problem with electric circuits (5/12/08), and when finding out a rusty nail attracted to a magnet but the “shiny,” aluminum nail did not, she exclaimed, “It's weird! Very surprising!” (4/10/08). Ms. Wolfe supported her enthusiastic claims to voice, especially when they were scientific. She gave Aaliyah the “final word” in a class discussion (11/30/07) and went to the classroom next door to get her a hand lens so she could observe fiddler crabs more closely (12/14/07). These fanciful connections allowed Aaliyah to “think like a scientist”: “Thinking like a scientist [means] you have to think other thoughts, how it would work, why it would work” (6/1/08). Her meanings reflect her solid understanding of the class's celebrated subject positions.

In small groups, she often knew immediately what to do and was so excited about the task that she bid to control the materials, which we viewed as *claims for space* and *claims to voice*. During a lesson where they examined closely and recorded observations of an African dwarf frog, a millipede, and a fiddler crab (12/14/07), she directed her peers in the proper handling of the animals (“Camilo, don't poke him—see what you're doing to his arm?”), the containers (“Mirabel, don't tap the container! You're going to scare him”), and the placement of the container on the table (“Put it in the middle! Here!”). These interactions also demonstrate her identity work of *standing up for the underdog*, with the defenseless animals as the underdogs.

Ms. Wolfe, when she saw it, re-directed Aaliyah's tendencies to control material, physical space, and activity and encouraged her to share. For example:

- [Aaliyah and Julio work on their animal chart, and Aaliyah reaches over to the part of the chart he is working on.]
- Aaliyah: Wait! Let me help you divide it. [She draws vertical lines in Julio's part of the chart]. Watch out! [She moves his hands to make space for the lines].
- Ms. Wolfe: [Visiting the group as Aaliyah draws the lines.] Julio, is that making you frustrated? The lines?
- Aaliyah: [Immediately stops what she's doing and steps back.]
- Julio: Yeah.
- Ms. Wolfe: Why? [Turning to Aaliyah]. What do we know about Julio?

- Aaliyah: Oh! He likes them straight (12/17/07).

Ms. Wolfe leveraged the figured world of family, holding Aaliyah accountable to respect Julio's physical space and identity work (as perfectionist) and providing direct instruction about how to better align herself with the nurturing celebrated subject position. Aaliyah's claims to space and voice were consistently tempered by an expectation of collaboration. Ms. Wolfe's reminders to be aware of and help others resonated quite well with Aaliyah, whose consistent identity work included *nurturing and standing up for the underdog*. We saw this identity work clearly when she worked one-on-one with students with less social capital. For instance, one day, she worked with Juan, who just recently arrived to the US from Mexico. Though it was officially an English-speaking day, she spoke Spanish the entire time she worked with him so that he could more fully participate (4/25/08). Further, she was one of the only students who worked well with Camilo, a bright, biracial boy who often had great difficulties working with his peers in groups.

Aaliyah's consistent identity work of claiming voice and space was leveraged in service of productive science engagement, which positioned her as well-aligned with the celebrated subject positions. Aaliyah recognized that she sometimes needed support to leverage her identity work productively. A year later, she credited Ms. Wolfe with helping her do so: "Ms. Wolfe disciplined me not to do weird stuff" (6/1/09).

### **Sixth-Grade Science: Figured Worlds and the Celebrated Subject Positions**

Mr. Campbell's classroom drew heavily from the *figured worlds of traditional schooling and traditional school science*. Class activities included mostly worksheets where students looked up answers in their books, whole class lectures, and an occasional cookbook laboratory. During lectures, he had epistemic authority and primarily used the I-R-E (teacher initiation, student response, teacher evaluation) discourse pattern (Tharp & Gallimore, 1988) to ensure students had the right answers. Consistent with canonical science, he positioned science as a body of knowledge that does not come easily: "Most of this [science] is not inherent knowledge ... I hate to say it, but a lot of this has to be memorized. Now, if you don't read the material, and you don't listen to me, you're at a distinct disadvantage" (4/22/10).

Students categorized the "asking questions" norm in the end-of-year card sort as something they did often, but when probed about the kinds of questions they asked, they said something along these lines: "He wants you to ask questions if you don't understand something" (Amy, 6/1/10). Their curiosity questions, when asked, received uneven responses. Sometimes, Mr. Campbell took time to offer narrative-like explanations, but other times he shut down questions. Aaliyah said that there was a norm of no "what-if" questions: "Like if a kid starts off with a what-if question, he'll be like, 'No what-if questions!'" (6/7/10). Most students did not seem bothered by the traditional school roles they were asked to play, describing his instruction as "interesting" (Mirabel, 4/12/10), "easy to follow" (William, 6/1/10), and "fun" (Amy, 6/1/10).

The figured worlds of traditional school science and schooling influenced one celebrated subject position—the “*perfect*” performer. When identifying the “smartest” science students at the end of the year, students used descriptors like “he’s a computer” (Wyatt, 6/1/10); “She’s a human calculator” (Aaliyah, 6/3/10); and “She knows all the answers” (Gianna, 4/19/10). Even the teacher, when naming top students, used grade point average (“perfect 100s”), the neatness of a planner (“her planner looks like typeface”), and the “perfect” project (“It’s just perfect”) as characteristics of top students (6/3/10). This positioning was not available to most students; the teacher named only White and Asian girls as top students in the end-of-year interview. These students also fit well within another available subject position—the *compliant student*.

Students who did their work, did not read (for pleasure) during class, were relatively quiet, and appeared to put forth an effort fit into the compliant student space. These students did well and seemed generally satisfied with their experiences in the class. This also translated into fairly low expectations. “In my class, if you turn in all your homework, you could probably fail all your quizzes and still get a B- or a B” (6/7/10). Amy said, “It’s easy for everyone to get good grades in science because if they try hard even if they don’t get every one right, they get good grades” (6/1/10). If students asked him a question during seatwork, he almost always provided the answer: “He gives us the answers if we don’t get it” (Mirabel, 4/12/10).

Mr. Campbell was hesitant to follow through on his “traditional schooling” figured world rules. He constantly reminded students not to read (for pleasure) during class, not to get up without his permission, and/or not to talk without raising their hand. Many students complied temporarily, but then went back to do the very things he asked them not to do.

I have a very hard time being mean to kids. I think their parents yell at them, I think they get yelled at, I think that I, as a White male, justifiably represent everything wrong with society. And if I get in a kid’s face and yell at them, think about the symbols, the images that my anger represents. You know, I don’t think I can get up in kids’ faces like that. So I usually try to take a calmer approach and in the process I probably put up with some stuff that some teachers don’t (6/7/10).

Yet, his patience occasionally waned with students’ disruptive behavior. Aaliyah astutely commented, “You never know which Mr. Campbell you’re going to get” (6/3/10). When he “snapped” (as he described it), Mr. Campbell was strict and authoritative. He admonished students for not attending to warm-up problems immediately upon arrival, for not being able to answer a question immediately, or for asking to go to the bathroom. In this mode, he invoked a *figured world of authoritative paternalism*, with a strict, “father knows best” persona, which promoted a *celebrated subject position of compliance*.

Mr. Campbell could also be funny and entertaining. One day, he sang students a self-composed song about electromagnetic waves, while playing his guitar and harmonica, and students cheered and clapped when he finished (4/13/10). His lectures often included storytelling, with dramatic

examples filled with danger, intrigue, death and destruction that were captivating for pre-teens. When talking about consumers and decomposers one day, a student asked whether cockroaches were consumers or decomposers, and he shared the urban myth that cockroaches would be one of the last species alive if there was a nuclear explosion because they can withstand large amounts of radiation (5/25/10). In these modes, he invoked a *figured world of adolescence*; drawing on examples the pre-teens might find entertaining, positioning students as *admirers* of, or at least *audience members* for his skills and narratives.

The figured world of adolescence was also invoked in his jokey banter with students. Adolescent humor is marked by their motivation to “fit in,” and therefore makes fun of undesirable behavior (Tamashiro, 1979). Further, adolescents, developmentally, begin to understand wit and sarcasm (Creusere, 1999) and use it to gain the attention of others and to buffer criticism (McGhee, 1979). Mr. Campbell called students by their last names, made up nicknames for them, and teased them, explaining: “It puts them at ease to have a little good-natured fun. This isn't Pink Floyd, *The Wall*, it's a happy place” (6/14/11). We interpreted some of his teasing as having sarcastic overtones. For example, he told students, “No offense, but you guys don't really know much” (4/30/10). These one-liners were always delivered with a joking affect. He did not agree that his humor involved sarcasm.

Pat Conroy said that, ‘Any good teacher has to have an element of insanity about them.’ And I think it's good to let the kids know that I might be a little bit crazy. I don't know, it's just fun to watch them laugh when you tease them, not sarcasm. There's never sarcasm. I don't hurt kids' feelings ... Sarcasm is used to inflict some sort of wound. That's the idea, is to make someone feel like crap. Mine is always good-natured, and they know it. It's fun to see them laugh (6/14/11).

Some students seemed genuinely entertained and even flattered when he teased them. For instance, Gianna thought Mr. Campbell was “really funny” because he called her Peggy Sue. However, he did not recognize that including some children and not others in the jokey banter and teasing was a form of exclusion, especially since that humor was used as a form of cultural capital. This nicknaming and teasing sometimes involved problematic gender positioning and heterosexism (as seen in the Peggy Sue example), which made the subject position unavailable and unappealing to, and/or uncomfortable for, students who were socially awkward, sexually immature, sexually questioning, did not have access to popular culture references or did not, for other reasons, appreciate or understand the forms of humor. This was a form of marginalization and othering (see Ryu, 2013, who talks about humor in the classroom othering Korean immigrant students, for example). These behaviors invoked a *figured world of hegemonic masculinity*, which, regardless of intention, bolstered his power and provided *less powerful subject positions* for students (Connell, 1996).

Readers who blame students' problematic positioning *solely* on Mr. Campbell's actions miss the point of our analysis. There are larger social structures bearing down on schools that lead well-

intentioned individuals, like Mr. Campbell, to reproduce the very dynamics they eschew.<sup>2</sup> Just as students had limited subject positions available and made choices accordingly so, too, did Mr. Campbell. His school district was socioeconomically bifurcated, including families from the highest socioeconomic classes to families living below the poverty line. Affluent parents put pressure on principals or teachers if their child was not doing well or if their children complained about the teacher. This pressure mounted in middle school. Parents worried about their children's academic success and used their children's grades as a gauge for their worry.

Mr. Campbell dealt with a wide range of student abilities and preparation. Many students were under-prepared because science was not a regular part of the elementary school curriculum, and funding cuts had eliminated supports for students with special needs. In one class, for instance, ten of his 29 students had individualized education plans (IEPs):

I wish I could do better ... I can't do it. They need help. And I can't give it to them. There's 29 students in there, ten who need help, five have behavior problems. I'm juggling bowling pins, chain saws, the whole thing ... I just can't do it (6/7/10).

There was pressure not to elicit complaints from students, parents, or his principal and to independently handle the increasingly difficult demands on time. He positioned himself as a compliant teacher who did not make waves or elicit negative attention from others. For instance, after hearing a teacher paged on the school intercom, he said, "It's not me, thank goodness. When I get paged, I get scared" (6/7/10).

Faced with these situations, he managed his class with familiar cultural models of schooling that did not evoke complaints, enabled most students to do well (as measured by grades), and entertained students. He had a good reputation. The principal spoke highly of him, and even the elementary teachers knew his reputation as a "great science teacher" (6/3/09). Many students liked Mr. Campbell and his way of teaching science. That many were happy in his class speaks to the invisibility of the oppressive nature of the norms of his classroom for those who were an ill-fit for, or had no interest in filling celebrated subject positions and the limiting nature of the norms for all learners' identity work as science learners. One goal here is to highlight how these seemingly innocuous practices became problematic for students (see Supporting Information Table 4 for summary of sixth-grade figured worlds and celebrated subject positions).

### **Sixth-Grade Science: Students' Identity Work in Relation to Figured Worlds and Celebrated Subject Positions**

The most striking aspect of sixth-grade science is its contrast to fourth-grade science. Students were held accountable to be *more* scientific in fourth-grade than they were in sixth-grade. Aligning oneself with celebrated subject positions had nearly nothing to do with engaging in scientific practices, thinking scientifically, or problem-solving. Further, students had different access to and interest in aligning oneself with the celebrated subject positions. Their consistent identity work had different and inequitable consequences for their positioning in sixth-grade.

## William

William's consistent *identity work as good student and pleaser* made the available subject position of “compliant student” fairly comfortable. It meant being able to work mostly individually and getting the right answers on warm-up questions, worksheets, or tests. One day during the warm-up, Mr. Campbell called on Julio, a struggling student whom William knew well from his K-5 dual-language cohort. When Julio hesitated, William jumped at the chance to prove that he had the right answer and/or that he could help Julio:

- Mr. C: Julio! Source of all life on earth is? [*Speaking quickly.*]
- William: [*loud stage whisper, seated behind Julio*] Sun!
- Mr. C: Julio, is?
- William: [*another stage whisper*] Sun! Sun!
- Julio: [*remains silent*]
- Mr. C: The sun. You don't have to shout it, William.
- William: [*laughs playfully and shouts*] Sun! (Video, 5/27/10)

Occasionally, William acted cooperatively with other students, for example helping a classmate collect students' papers even though no one had asked for his help (Video, 5/6/10). However, consistent with the figured world of traditional schooling, most of his identity work was leveraged in service of individual accomplishment, and he gauged his success by his grades: “He wants to know what he got on his quiz as soon as I know” (6/7/10). This is a shift from fourth-grade, when others labeled him “smart” student because he was a good collaborator.

William's consistent *identity work as conscientious/worrier and pleaser* was leveraged to ensure that he did his work, focused on an activity's procedure, and got the right answer. Mr. Campbell's emphasis on closed-ended tasks worked well for William. His fifth-grade teacher described him as “a very cautious student ... He likes known-answer questions” (6/1/09). Mr. Campbell described him as an “absolute pleaser ... he wants to make me happy. He studies, works hard ... he's diligent about turning in work” (6/7/10). William was nearly always on-task during group work, acknowledging, “I do stay focused and pay attention. I don't play.” (6/1/10).

During a small group research project about bears, William positioned himself as the group leader, which meant ensuring that everyone completed their tasks. The three students in the group researched Black Bears, and William's goal was to effectively represent the knowledge on a poster. He was as task-oriented as he was in fourth-grade, but the three boys did not necessarily work together. William occasionally asked them about the organization of the poster or the appearance of a drawing. In the following example, William worried, not about the science, but

about making the poster look good. When a researcher asked him how the bear project was going, he responded:

- William: Not so well. [*Without looking up.*]
- Researcher: Why?
- William: There's no black. [*As he's coloring in the bear with a black crayon.*]
- Researcher: You have black right there. [*Points to the black crayon.*]
- William: No black colored pencils. [*He doesn't look up and continues coloring.*] (Video, 5/20/10)

William explained that “being creative” was not a stressed norm in the class but mentioned the bear project as an exception. “[Mr, Campbell] wanted us to ... make the poster as colorful and beautiful and creative as we can. Like drawing extra pictures like a bear trap. Or people setting up bear traps” (6/3/10). William's conscientiousness was leveraged only toward thinking about the project's aesthetics, and he had no opportunity to develop an understanding of the ways creativity is used in science.

His *conscientiousness* and *pleaser* identity work positioned him within the valued subject position of compliant student. Mr. Campbell appreciated William, described him as a hard worker, someone who “really does have ambition” and “does fine—he's not a crackerjack student, but then again, he speaks two languages ... you're not going to find a sweeter kid” (6/7/10). He did not fit into the “perfect performer” celebrated subject position. As a boy who had not yet reached puberty, he was smaller than his classmates, and he did not quite fit in with the more athletic, popular boys who engaged in jokey banter. Mr. Campbell described him as “this cute kid” with an “adorable thing going on” (6/7/10), a positioning that was problematic for William's access to the celebrated witty, joking repartee subject positions. For example, we observed him laughing nervously, awkwardly, or a little bit late or loudly at the teacher's jokes.

William recognized himself as sharing some characteristics of the “smartest” students, like “paying attention,” but he said that he took longer to complete tasks than the smartest students. It was clear to us, however, that he had learned a lot of science content, as his end-of-year interview was peppered with specific examples of the science he learned during the year. He liked sixth-grade science and, in fact, described Mr. Campbell as the one who had the most impact on his potential future career choice: aerospace engineering. He was not bothered by fewer opportunities for hands-on, scientific investigations, explaining that Mr. Campbell “makes science fun” (6/3/10). However, we did not see opportunities for him to leverage his good student and conscientious identity work in service of scientific reasoning, problem-solving, and curiosity as he did in fourth-grade. Instead, he filled the compliant student subject position, which meant paying attention, displaying his science knowledge, and getting the right answer.



## Amy

Amy's *adaptable good student* and *pleaser* identity work persisted in sixth-grade science. “She was one of the girls in the running for the [end-of-year] science award ... Talk about a pleaser. What a hard working little kid” (6/7/2010). Amy was, in fact, positioned within the narrowly defined, celebrated subject position of the (near) perfect performer. “I mean, she might get a 98 here or there, but mostly it's 100s. [She is] very bright, and she is diligent. I bet her planner is perfect” (6/7/2010). Comparing the top students in his class, he said that Amy was not *quite* the “answer key” that one of her peers, Isabel (a White girl) was, and she did not have the planner that looked like “typeface” like Atsuko (a Japanese American girl) did. Nonetheless, she was, he said, clearly one of the “top 15 students” in the sixth-grade. He liked and appreciated Amy, giving her the nickname of “Cacahuete” (“peanut,” in Spanish).

She easily adapted to the shift from a more student-centered, hands-on, discussion-oriented elementary science to the bookwork, fact-based, teacher-centered science. Though she admitted that most of the classwork involved “boring” worksheets, she described Mr. Campbell as “fun” (6/1/10), loved when he tried to speak Spanish, especially when he dramatically trilled his “Rs” or playfully used a southern accent.<sup>3</sup> “He talks like a Gringo! ... He makes the class fun [and] gives us funny examples ... I just think it's funny hearing him talk and talk” (6/1/10).

She described herself in ways that demonstrated her consistent identity work as a *good student* and *pleaser* of both her peers and teacher. “I'm loud, energetic—I want to learn—I ask a lot of questions, that's what I mean by loud. I help a lot of people, I'm helpful” (6/1/10). As in fourth-grade, we often saw her helping and working with classmates during “independent” work. Though not always encouraged (“Sometimes he wants us to work with a partner, sometimes he doesn't”), she and her seatmates (including Aaliyah) would often work together to complete worksheets and/or study guides assigned in class (4/15/10; 5/27/10). We saw this gentle form of resistance as, perhaps, a way to make the mundane seatwork more efficient and enjoyable.

Her performance as *good student* meant doing her work and asking questions. Yet, her questions were often about answers on worksheets. The following interaction was fairly typical:

- Mr. Campbell comes over to Amy to help her with her worksheet, at her request.
- Mr. C: Do you remember this one? [*Pointing to one of the blanks on her worksheet.*]
- Amy: No. Um. (*Pause*) Timbre?
- Mr. C: Timbre, that's right. [*He taps her on the shoulder gently.*]
- Amy: Is this one pitch?
- Mr. C: Yes, that's pitch. [*He begins to walk away, but she calls him back to ask for another couple of answers.*] (4/30/10)

Amy did not necessarily seek recognition for her scientific problem-solving as she did in fourth-grade, nor were those kinds of opportunities necessarily available. Instead, she sought recognition for her diligence and good student identity performances. It is telling that, in the above example, Amy seemed to actually know a couple of the questions she sought from the teacher. In fourth-grade, she occasionally asked for answers, but Ms. Wolfe did not comply. Mr. Campbell did so repeatedly. Unfortunately, her answer-seeking positioned her submissively. When she went into the question-asking mode during independent work, her voice went higher, and she put on a “cute” affect, a kind of mainstream gendered performance—“Where do you find the rest of the habitat, Mr. Campbell? Mr. Campbelllllll???” (5/27/10). He explained, “Yes, she's a little dreamy sometimes, she'll get stuck on a question and be like, 'I don't get it'” (6/7/10).

One explanation for this shift in identity performances—from problem-solver in fourth-grade to answer-seeker in sixth-grade—is that this was one of the only “good student” subject positions available if one wanted to get the teacher's attention. When he was not helping students with worksheets, he engaged in off-task conversation or banter with other students (a subject position uninteresting for Amy) or corrected students' off-task behavior (which also did not apply to Amy). She explained, “Lots of people don't speak up in science. Sometimes he forgets they're there” (6/1/10). Perhaps she asked lots of questions so he would continue to notice her. Mr. Campbell explained that he “work[ed] hard to give students like Amy ... the attention they want” (6/7/10). Amy implied that her question-asking may have been a way to please the teacher: “But if you understand it, you can still ask a question. He likes answering questions as you can tell because he goes on and on about the question” (6/1/11).

She was more easily able to perform herself as problem-solver in her technology/engineering class, which was her favorite class. Her mother said, “She enjoys all of her subject areas, but she gets a real kick out of the technology class. I think she just likes doing stuff with her hands and thinking.” She mentioned Amy's excitement when her mousetrap car outperformed her teacher's model car (10/7/09). Amy's work ethic, desire to please, and adaptability persisted in sixth-grade, but instead of promoting strong scientific identity work, it served only to strengthen her ability to “do school” well. No longer did she endeavor to create experiments, ask questions, or answer her own questions, as she had in fourth-grade.

## **Aaliyah**

The figured world of traditional schooling, with norms of “sitting still and raising one's hand to speak ... preferred over continuous movement or calling out one's thoughts” (Kane, 2012, p. 460) was especially impactful on Aaliyah's claims to voice and space. Students' desk arrangements (in rows in front of the teacher's bench) and classroom norms to ask permission to leave their seats for any reason made *claiming space* difficult. However, she used the small bit of physical desk space that she “owned” in subtly resistant ways. She often had a snack with her and would unabashedly eat the snack during class, sometimes with a dramatic flourish (e.g., eating peanuts by clapping her hand to her mouth, 5/27/10). Other students with snacks ate in

more clandestine ways. She also claimed space by sometimes reading for pleasure during the “warm-up” or question/answer sessions that followed (3/25/10; 4/13/10; 5/5/10).

Aaliyah occasionally tried to *claim voice* to contribute to class discussions. However, Mr. Campbell shut down her contributions if he interpreted them as silly and often reminded her firmly to raise her hand before talking. He said, “Aaliyah believes that she's on a television show. She believes that there's a laugh track for everything she's doing, and that people are watching. It's that adolescent narcissistic thing. It's fine. It's adolescence. Sometimes she drives me up the wall” (6/7/10). While Aaliyah liked to get a laugh from peers, she also made bids to share fanciful and creative connections to the science content as she did in fourth-grade. One of the celebrated subject positions was to admire Mr. Campbell's humor, but instigating the humor was largely unwelcomed. One day the class was discussing black holes, and Mr. Campbell wondered out loud what one might look like after getting sucked into one. Aaliyah said, “Yeah, you'd look like a noodle if you ever got out,” something she saw on the Discovery Channel. He smirked at her and called on the next person (6/3/10). In several instances, Aaliyah provided comical, but creative and viable scientific contributions that Mr. Campbell actively silenced by “shushing” her (5/27/10). Aaliyah recognized this silencing.

I'll use examples that don't even have to do with science ... the way I say it, it makes it look like it's not science-related, but he knows it is, so those are the things he kind of doesn't want to hear. That's why he doesn't want to hear my opinions (6/3/10).

Mr. Campbell described Aaliyah in the end-of-year interview this way:

She's got a great brain. I think sometimes she's got a smart mouth. She talked back to me today about something, I shushed her and she shushed me back. That was like, 'Whoa, that's the kind of thing that will get you in a lot of trouble.' And she backed off ... She'd be right there in the running for that award at the end of the year. If she kept up with her planner and be a little quieter during class. Not quiet, she doesn't have to be a shy little girl, but she is just not behaved (6/7/10).

Here, we see evidence of the gendered, raced, compliant, perfect performer celebrated subject position that was completely unavailable to Aaliyah, given her consistent identity performances from fourth- to sixth-grade to claim voice and space.

Aaliyah recognized that his tight reigns on students' claims to space inhibited them from helping each other. “If it involves getting up and moving, no. He doesn't expect [you to help others] ... He doesn't want you getting up to go talk to anybody even if it involves helping people” (6/3/10). While many students worked individually, Aaliyah's seatmates (Amy and Naomi) consistently worked together, sharing answers and sometimes one textbook between the three of them. Aaliyah was often on-task during seatwork, even though she described it as “boring stuff” (6/3/10). Like Amy, she worked in a socially nurturing way, even though this was not a

promoted classroom norm. We interpreted this as another subtle act of resistance, a way to leverage her consistent identity work as *nurturer* to make the “boring” seatwork more enjoyable.

Aaliyah seemed to “read” unjust classroom norms and practices in a more sophisticated way than many of her classmates, and/or she was more willing to claim voice to object to these practices. Motivated by more than positioning herself as a “good student” and reflecting her consistent identity work of *standing up for the underdog*, she was one of three students we interviewed (out of 13) who expressed annoyance with Mr. Campbell's humor: “He tries to make us laugh, but you can tell, it's not funny ... I just find him annoying, like for some reason, I just do” (6/3/10). As an example of her unwillingness to adopt the admiring fan subject position, she was one of the only students not to clap for his electromagnetic wave song. She openly objected to some of his attempts at humor, which we saw as her way of *standing up for the underdog*. She was also the only student we saw who *claimed voice* to object to his sarcastic comments:

- Mr. C.: I know it's not really in vogue these days, but I have to ask that you read. I know, I'm sorry. No offense, but you guys don't really know very much. You're 11 and 12 years old right? You can't know everything—
- Aaliyah: [*Lets out a dramatic gasp and says, in a stage whisper*] Offensive!
- Mr. C.: Shhh! [*In response to Aaliyah*] You can't know everything when you are that age. I don't know everything! (4/30/10)

On another day, he had all students turn in their papers to Gianna. He turned to the researcher and said playfully, “I love to see her (Gianna) in a panic.” At one point, Gianna looked overwhelmed, though not upset, while trying to gather all the quickly incoming papers and said, “One at a time!” while Mr. Campbell laughed. Aaliyah was the only one to speak up in Gianna's defense. “Mr. Campbell, are you enjoying this?” After everyone left, he gave Gianna some candy to take with her. We interpreted Mr. Campbell's actions as drawing on a figured world of jock masculinity, teasing her into a position of powerlessness that we found uncomfortable. Aaliyah was the only one to speak out against Mr. Campbell's positioning of Gianna. Often, Aaliyah performed her resistance with savvy— she did it with a lighthearted, mock-offended affect, which resulted in getting Mr. Campbell's attention.

At the end of the year, Aaliyah explained that she “wasn't really a science kind of person” (6/3/10), and she did not like Mr. Campbell or his pedagogy. She had divergent, creative ideas about what her ideal science class would be like:

- Aaliyah: I like thinking about science in my future, even if it's not reasonable, like thinking about making wings so you could fly ... Everybody likes to be creative, express themselves ... Everybody has different ideas they want to share ... I want my people to talk, I don't want to see you just sitting there, doing your work but not talking, I want you

to say what you're thinking about like, if you think this is wrong in the science book: explain why.

- Heidi: You know whose class you sound like you're describing? Guess.
- Aaliyah: [*confidently and without hesitation*] Ms. Wolfe's! (6/3/10)

## **Discussion**

### **Cultural Production of Fourth-Grade Science**

By the end of fourth-grade, all three students affiliated with the culturally produced meaning of “smart science student” and did identity work to position themselves as aligned with celebrated subject positions. Their identity work looked different; they had different strengths, interests, and resources to draw on and were all “smart in different ways” (Ms. Wolfe, 8/3/08). However, celebrated subject positions were broadly construed enough to accommodate and leverage different kinds of social identities in service of productive science engagement.

The meaning of science was a cultural production that challenged status quo meanings of school science. Students came to understand that being a “good” and “smart” science student meant thinking critically, persisting, problem-solving, making unique observations, and creating scientific explanations and also being empathetic and nurturing with peers. In contrast, Varelas, Kane, and Wylie (2011) report that students as young as first-grade create meanings of “doing science” that are deeply intertwined with norms and practices designed to control and regulate behavior (“doing school”). They describe a “pedagogy of control” that emphasizes regulatory behavioral norms and has potential to diminish “thinking out of the box” and other robust scientific identity work (p. 834). Further, celebrated subject positions in prototypical school science not only impoverish scientific engagement, they “often exclude the behaviors, vernacular, interests and various other forms of capital associated with youth culture” (Gonsalves, Rahm, & Carvalho, 2013, p. 25). We saw Ms. Wolfe's classroom as challenging these enduring meanings of school science. Our fourth-grade case provides evidence that students from all kinds of backgrounds and with widely varying previous science experiences and interests, are capable of and interested in performing themselves scientifically when given robust opportunities to do so.

### **Social Identity Work Leveraged in Service of Science**

In fourth-grade, all students benefited greatly from the fact that their social identity work was leveraged in service of learning and doing robust school science. In other words, what counted as “being scientific” was tightly interwoven with what it meant to “be Aaliyah” or to “be William.” This meant that their identity work was much less problematic, contentious, and/or threatening. Amy's social adaptability allowed her to quickly assess classroom norms, meet them and often exceed them. She was capable of enacting fourth-grade school science in evermore robust ways,

by “always thinking of new experiments to do.” William's “worrier” identity work led to conscientious performances that manifested as commanding the attention of his group and thinking critically to solve scientific problems. His fastidious attention to detail therefore became an asset to, and helped sustain, the classroom's social and scientific norms. The tapestry of the classroom afforded Aaliyah the space to claim voice and space to provide evidence-based explanations of scientific phenomena, investigate and describe animals in creative ways, and emotionally invest in the science, while also holding her accountable to share space and voice with classmates.

### **Problematic Trajectories Over Time**

As students progressed to sixth-grade, they began to experience troublesome scientific trajectories in various ways. While Aaliyah began to resist and disaffiliate with school science, William and Amy continued to strongly affiliate, doing consistent identity work to position themselves as aligned with celebrated subject positions. However, doing so did not require the rich, multi-faceted, scientific performances celebrated in fourth-grade science. Others have also written about the problematic narrowing of school science pedagogy and curriculum (Brickhouse et al., 2000; Shanahan & Nieswandt, 2011).

At first glance, it would appear that both William and Amy continued on similar successful pathways, with excellent grades and teacher praise for their performances. In sixth-grade, William aspired to become an aerospace engineer, and Amy's teacher singled her out as one of the best science students. However, our analysis paints a more troublesome picture. Although William and Amy continued to perform themselves as academically “good students” in sixth-grade, their scientific performances required less robust engagement of their social identity work. Amy, adaptable to any situation, easily discerned the norms of the classroom and requirements to align oneself with the celebrated subject positions. In doing so, she no longer held the floor to share scientific questions, observations, or inferences, nor did she make sophisticated scientific bids for recognition. William, a worrier by nature, was not encouraged to take risks, think creatively, and problem solve in ways that might provide him with resources for future identity work in science. Unfortunately, these fully capable and motivated students' successful identity work in narrowly constructed sixth-grade school science promoted precarious science trajectories. Even more vexing, however, is Aaliyah's trajectory. Though one of the smartest and most engaged girls in fourth-grade, she was unable and/or unwilling to position herself in ways that aligned with the celebrated subject positions in sixth-grade even though she was fully capable academically.

### **Race, Class, and Gender Figured Into Students' Successes in, Threats to, and Identity Work Related to Becoming Scientific**

Amy seemed to have the easiest time aligning herself with the celebrated subject positions in sixth-grade. Amy's race and class were not barriers to achieving success. Regardless of how the

requirements for being a “good student” varied across contexts, Amy wanted to meet those requirements. She was successful, in part, because she knew how and was motivated to “do school.” Her economic privilege gave her opportunities to enroll in extracurricular activities, some of which gave her additional social capital in school science (e.g., science camp, Lego camp). Further, her stable home life afforded her less tumult and more time to focus on her studies. She affiliated so closely with school that she wanted to be a teacher. While the sixth-grade teacher perceived other students as rebellious, resistant, or deviant in ways that were related to racial/linguistic stereotypes, Amy, as a White student, did not run that risk. She even proudly described herself as “loud” in a class where norms were largely about students' silence. This self-description illuminated her racial privilege when we compare Mr. Campbell's negative reactions to Aaliyah's “loud” performances. Amy's identity work enabled her to distance herself from being seen as a resistant *or* divergent thinker, bolstered by the figured world of adolescence, which celebrated “fitting in.”

However, a study of high-achieving 12- and 13-year-old boys and girls in England illustrates how “performances involved in the production of such ‘effortless’ achievement are themselves far from effortless” (Francis, Skelton, & Read, 2010, p. 336). Amy had to do considerable gender work to align herself with celebrated subject positions. She positioned herself as a smart, confident girl, but not *too* smart or confident. The celebrated subject position was for students who knew a lot and/or who performed required work with perfection, but who were not “know-it-alls.” She toned down her power (her confidence, her intellect) to make bids of helplessness to the teacher, which was a primary way to get recognized by him. When Amy asked the teacher for help with a question on a worksheet, she did not completely avoid certain problematic, raced and gendered stereotypes of shyness and passivity. Though clearly not shy in asking for help, she did so with a sing-song delivery (“Mr. Campbellllll”) that positioned her with less power, and she actively sought out answers that she may or may not have known, from a sanctioned source of knowledge (the teacher). Her performances align with Francis et al.'s (2010) argument about high-achieving girls; they have to balance submissiveness with “traditionally masculine aspects of performance that denote ‘success’ ” (p. 326). At the same time, her “tomboy”/athletic gender performances protected her a bit from some other problematic gender positioning we saw from girls who had reached puberty and performed heterosexualized femininity. For instance, some girls tried to get Mr. Campbell's attention in inappropriately familiar or even flirtatious ways (e.g., tapping their pencil repetitively on his arm or loudly teasing or praising him for his singing). Amy's pre-pubescent and tomboy status protected her from doing gender in those ways but still positioned her as submissive and less powerful than she was in fourth-grade. Mr. Campbell's nickname for her (“cacahuete,” peanut in Spanish) and descriptions of her (“a hard working little kid”) are illustrative of this positioning.

William also worked hard to be recognized as a “good student” in the context of sixth-grade science, but his identity work was more troubled. It was quite worrisome work, literally, for William to figure out how to mold himself into celebrated academic spaces of the classroom,

while also maintaining credibility amongst his peers. We understand his difficulties more clearly when we attend to the ways the celebrated subject positions in sixth-grade science privileged certain performances of masculinity, which also intersected with race and class (Archer, DeWitt, & Willis, 2014). William did not easily do gender in the “laddish” ways (underachieving, being disruptive or disengaged, having a “laugh”) that some of his Latino male friends did (Jackson, 2002). Nor could he *quite* perform himself with the calm, rational, confident “muscular intellect” prevalent among upper-middle class, White, high-achieving boys (Archer et al., 2014). Further, he was unable to easily engage in the witty, joking repartee that was relatively easy for mainstream, White, more physically mature and athletic boys. He was not one of the “cool” boys; Mr. Campbell described him with feminine descriptions of “cute,” “sweet,” and “adorable.” His fifth-grade teacher’s description of him as a “goody-two-shoes” and “Mr. Perfect” similarly position him as less “cool.” While a match for the compliant student space, these performances put him at a disadvantage amidst the figured world of hegemonic masculinity and adolescence privileged in the classroom. Here, we see the tricky negotiations and difficulties of filling either of the celebrated subject positions—the jokey banter space or the perfect performer space. The space he filled quite well, the compliant student space, required performances of diligence and care, commonly associated with femininity (Francis et al., 2010). Sociologists have written about the ways boys who are seen to work hard and behave risk getting positioned as effeminate (Francis et al.). William’s difficulties in aligning himself with celebrated subject positions were tied up in the gendered, raced, and classed nature of those positions.

William expressed worry about his academic performance during every end-of-year interview. Before fifth-grade, he “worried the whole 2 months of [summer] vacation” about science because he thought that the end-of-grade science test would be “hard” (6/1/09) and sixth-grade brought worries that middle school science would be too difficult (6/3/10). He worked diligently, but had difficulty getting positioned as a top academic performer. For instance, he was not recommended for the AIG program like Amy and Aaliyah were because he was too careful of a student, “not a creative thinker” (Teacher interview, 6/3/09). His ethnicity and social class seemed intertwined with his careful identity performances and his positioning by others. As the oldest sibling in a first-generation immigrant home where everyone spoke Spanish, William’s identity work in school was higher pressure and less seamless than Amy’s. He was expected to set an example for his younger siblings, and his parents placed strong, instrumental value on formal schooling (Parent interview, 9/15/09). He regularly helped his father in their home garden but, overall, he had less access to out-of-school science experiences than Amy. He did not attend science camps, did not have green or open space near his house, and may not have had as many opportunities for science-related play. School science, therefore, was *higher stakes* for William than it was for Amy, who could draw on multiple, out-of-school contexts to fulfill her consistent problem-solving identity work. He had high aspirations—to become an aerospace engineer, a trajectory that demanded rigorous preparation in mathematics and science, making it all the more important that he had access to quality *school* science education. Mr. Campbell positioned William as a somewhat *unusual* Latino boy because “he really does have ambition” (6/7/10), indicating a



deficit-based lens. Though race, class, and gender figured into his identity work and positioning, his conscientious worrying and persistence through a more difficult science trajectory could also be seen as a resource he might draw on in future school science experiences.

Although all students experienced problematic identity trajectories, Aaliyah's trajectory is further complicated due to her location within the matrix of oppression (Johnson et al., 2011). In fourth-grade, Aaliyah was recognized as confident, competent, and engaged in science and academics. In fifth-grade, Aaliyah was identified as an AIG student. While she received good science grades throughout the study, the fourth-grade classroom productively leveraged social identity work that was problematically intertwined with race and gender by sixth-grade. For example, her bids for control (of materials, ideas, plans to complete tasks) and outspokenness (“whacky” ideas and standing up for the underdog) got interpreted as “loud Black girl” (Fordham, 1993) performances in negative, unproductive ways. Aaliyah's teacher positioned her as having a “smart mouth,” underperforming, and “just not behaved” (6/7/10). Whereas he worked to accommodate Amy's attention-seeking (“I work hard to try to give *students like Amy* the attention they want”), Aaliyah's attention-seeking got framed as “driv[ing] me up the wall” (6/7/10). As a physically mature, African-American girl who was willing to claim voice, the more desirable “cute” and “sweet” subject positions (though problematic in their own ways) were not available to Aaliyah, nor was she willing to consistently perform in the compliant student space. She was unwilling to perform heterosexualized femininity in sixth-grade, which was another available space for girls. Mr. Campbell did not engage in jokey banter with Aaliyah in the ways he did with the students with more cultural capital, though that is one way she tried to engage him as she voiced her objections with a “mock-offended” affect. Nearly all the celebrated subject positions were problematic, either because she did not see them as viable for who she was or wanted to be and/or because those spaces were simply not available to her as a confident, African-American, physically mature girl who liked to claim voice and space in service of creative, divergent thinking. However, she played the game well enough to earn decent grades (As and Bs).

High-achieving ethnic minorities, and especially African-Americans, face considerable identity work challenges as they simultaneously try to fend off undesirable identities ascribed to them because of their race, but also avoid “acting White” for fear of derision from their ethnic minority peers (Ogbu, 2004). Archer's (2012) discussion of the “minority ethnic middle class” illustrates additional complexities social class brings for those who find themselves “at the nexus of class privilege and racial subordination” (p. 133). In her study, the minority ethnic middle class was “constructed as hard working and aspirational” (p. 136) (values Aaliyah and her mother espoused), but their identity work was made precarious by threats of being seen as pretentious and/or inauthentic (“forgetting your roots”). The same threats were likely there for Aaliyah. As one of three African-American girls in the class and yet drawn to the high-achieving girls from her dual-language cohort from elementary school (mostly Latina and White), Aaliyah likely had to engage in complicated ethnic identity work to figure out how to position herself.

Aaliyah's case resonates with other studies of academically talented, science-interested African-American girls' and women's tumultuous science trajectories in recent science education literature. These stories illustrate how their trajectories are racialized, so that their behavior that did not fit mainstream, White, gendered norms became more salient than other identity work such as being interested and talented science students (Malone & Barabino, 2009). For instance, in Brickhouse et al.'s (2000) longitudinal study of four African-American girls, Tanisha, a girl with strong scientific interests, assertively claimed voice in science class in ways that positioned her problematically in relation to normative “good girl” roles, threatening her science trajectory as she was placed in lower track science classes for high school. Tan and colleagues (2013) describe Kay, an outgoing African-American girl with aspirations to become a doctor and strong affiliations with altruistic, “make-a-difference,” “community science expert” identities-in-practice of an after-school Green Club. However, she was bored with school science and, like Aaliyah, was willing to speak up against treatment she interpreted as unjust. Her seventh-grade science teachers' described her as a “big behavior problem” (p. 22), and her positioning in school science threatened her aspiring trajectory of becoming a doctor. In these two examples, Tanisha and Kay broke school-sanctioned, mainstream gender and behavior norms which became more salient for teachers' recognition of them than was their strong science potential (Varelas et al., 2011). A third example comes from Carlone and Johnson's (2007) longitudinal study of 15 women of color who successfully pursued science-related careers. They found that all but one of the Black women in the study experienced the “thwarted” science trajectories and described how Black women's “bids for recognition were disrupted when they were recognized not as science students but, instead as representatives of their ... racial groups” (p. 1211). Mutegi (2013) argues for science education literature to take seriously the “centrality of race and racism in shaping the science education of African-Americans” (p. 87). These recent studies of science education demonstrate the ways some science-interested and talented African-American girls and women get constructed as an ill-fit for school and university science's celebrated subject positions and/or have to mold themselves into those subject positions by denying parts of themselves, making it difficult to be authentically oneself within the dominant social order (Archer, 2012).

We can also examine Aaliyah's identity work and problematic positioning from a “resource” point of view. For instance, the fact that she could read sixth-grade classroom norms as problematic, while her peers considered them normal, was an intriguing resource. Johnson et al. (2011) found a similar skill amidst women of color who successfully navigated science trajectories amidst raced and gendered spaces of science work and learning. Following Anzaldúa (1999), they describe the women as having *la facultad*, the ability to read and quickly respond in a way that allowed them to navigate, as safely as possible, oppressive structural arrangements. *La facultad*, Anzaldúa argues, is a “survival tactic” of those “pounced on the most” (pp. 60–61). Wiederman (1985) similarly argues that African-Americans need a “seventh sense”:

If you are born Black in America, you must learn to quickly teach yourself to recognize the invisible barriers disciplining the space in which you may move ... Nothing is what it seems. You must always take second readings, decode appearances, pick out the abstractions erected to keep you in your place. Then work around them (p. 222).

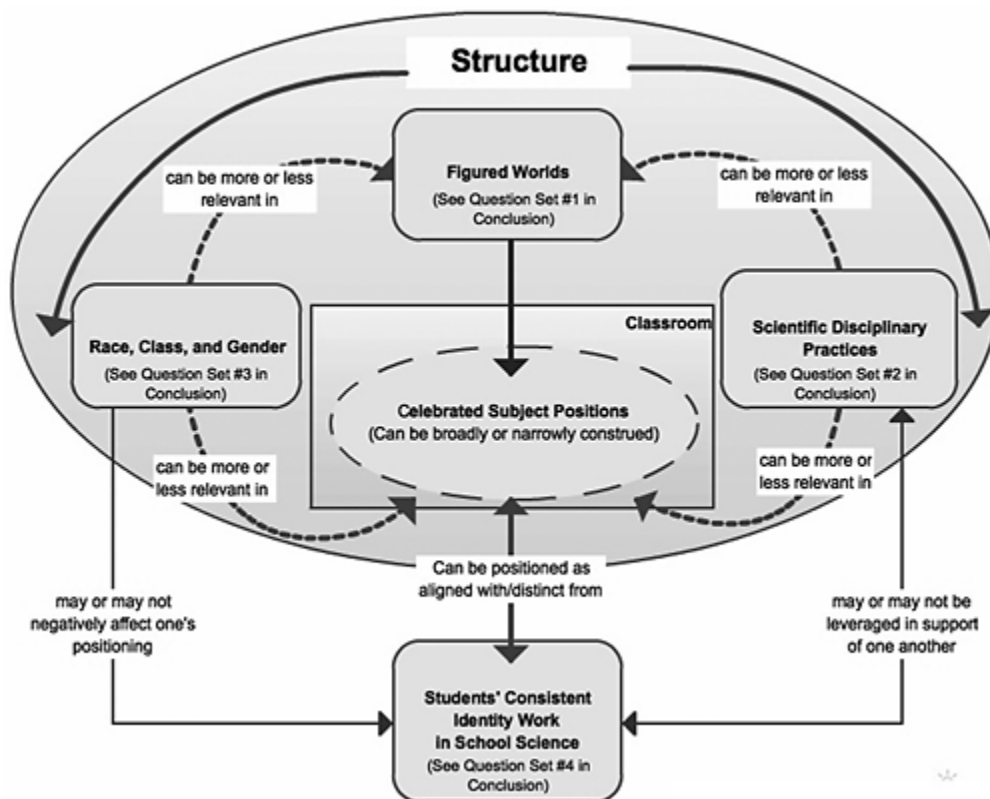
Aaliyah could read the classroom's oppressive structures, well on her way to developing *la facultad* or a “seventh sense.” As an 11-year-old, she was still learning how to respond to navigate the structures in the safest ways possible; in ways that did not further threaten her academic trajectory. We view her potential to cultivate *la facultad* as an encouraging sign for her academic and scientific trajectories, but the need for her to do so is unjust (Johnson et al., 2011).

## Conclusion

We began this manuscript by acknowledging the large body of literature that discusses the widespread problem of students' declining science interests in middle school. When we embarked on the study, we hoped for a different story to tell—a story of optimism, hope, and the sustainability of strong elementary school science experiences. Unfortunately, the students' experiences and identity work tell a story that is largely aligned with cultural reproduction of the status quo and the marginalizing effects of traditional school science. Each of these cases demonstrates the ways race, class, and gender figure more prominently and problematically into students' identity work by sixth-grade, which aligns with work by sociologists of education, who argue that dominant constructions of the “ideal student” are raced, classed, and gendered (Archer, 2012). What do we know about the middle school science problem that we did not know before?

There very few longitudinal studies of students' school science engagement in these critical years of early adolescence, and fewer these studies take an in-depth, first-hand look at everyday science classroom life. Our approach emphasized understanding the meaning of students' social identity work in the cultural context of each year of school science. Doing so allowed us to peek into the black box of school science to understand some of the implicit processes that likely contributed to students' problematic science trajectories. This study emphasizes the difficulty of prototypical school science in sustaining and buttressing nonmainstream students' meaningful science trajectories. School science is subject to strong institutional and cultural narratives of what counts as legitimate science, is often configured too narrowly, and leaves little room to celebrate and productively leverage different kinds of students' science-related interests and identity work. However, the fourth-grade science case points to the promise of disrupting those dominant narratives. The question remains—is it possible to re-figure a *middle school science classroom* in similarly accessible ways when structures of race, class, and gender become increasingly salient in the social lives of adolescents and in the figured worlds of traditional schooling and school science? How can we begin to imagine such a space? Our framework, fleshed out with lessons learned from this study, provides a starting point (see Figure 1). Below, we pose four question sets we would ask ourselves (based on the framework in Figure 1) that

provide a continuation of previous literature for designing and/or evaluating middle school science classrooms with an eye toward equity and accessibility. The questions we raise here have not been prominent in previous literature examining the middle school science problem.



**Figure 1.** Theoretical framework that can be used to guide evaluations and creations of equitable science learning settings.

### Question Set 1

Figure 1 shows that the kinds of figured worlds that influence the classroom shape the nature of the celebrated subject positions. Thus, to evaluate equity in a given setting, we would first ask ourselves what figured worlds (at the macro-level timescale) are relevant for and evident in the classroom norms and celebrated subject positions? In other words, what widely circulating cultural narratives help define what and who counts as legitimately scientific? Do the classroom norms leverage multiple, empowering, youth-centered figured worlds? As was the case with fourth-grade science, doing so in middle school may help “validate youths' resources and histories” (Gonsalves et al., 2013, p. 27), allowing them to see overlaps between who they are and who they are expected to be in science.

### Question Set 2

Second, we would ask about the relevance of *scientific* disciplinary practices in the nature of the classroom's celebrated subject positions to evaluate the equity of a science learning setting (see

right side of Figure 1). Is performing oneself scientifically an obligation of aligning oneself with celebrated subject positions? In fourth-grade science, students' social identity work was leveraged in service of performing themselves scientifically and, in sixth-grade, scientific practices were, at best, marginally relevant to performing themselves as “good” students. We see the emphasis on engaging students in scientific and engineering practices in the *Next Generation Science Standards* (NGSS Lead States, 2013) as productive for designing and evaluating equitable classrooms. Holding all students accountable to engage in scientific practices builds understanding of science and language proficiency (NGSS Lead States, 2013), but it also has potential to disrupt dominant narratives of traditional schooling that conflate “good behavior,” and “good science” (Varelas et al., 2011).

### **Question Set 3**

A third aspect of the model (see left side of Figure 1) prompts questions about the relevance of race, class, and gender in the construction of the classroom's norms and celebrated subject positions. Do the cultural meanings of “good student” celebrate prototypical performances of White, middle class students? Are mainstream “good girl” or “cool guy” performances celebrated? How are non-normative performances silenced, re-directed or leveraged? Do all students, given their histories and resources, have equal opportunities to fill the celebrated subject positions? In what ways do students' race, class, or gender become resources or disadvantages? How salient is their location along the matrix of oppression to their abilities or motivation to position themselves as aligned with celebrated subject positions? These questions are perhaps the most difficult because of the subtle and unconscious ways race, class, and gender are structuring resources in North American schools (see Parsons (in press), who makes an excellent argument regarding the invisibility of race, even amidst literature claiming to address it). However, this also speaks of the urgent need for teacher educators, professional developers, and educational researchers to educate others, especially those from dominant social groups, to denaturalize, critique, and develop workable strategies to disrupt the status quo.

### **Question Set 4**

As indicated by the lower half of Figure 1, evaluating the equity of a science learning setting means understanding the alignment of students' identity work with the setting's celebrated subject positions. How easy or difficult is it for students to be “who they are” and want to be in school science (Tan et al., 2013)? How aligned is students' consistent identity work with the cultural meaning of “good” or “smart” science student? Is their social identity work leveraged in service of engagement in meaningful scientific practices? Our findings suggest that the more overlap between students' consistent identity work and the classroom's celebrated subject positions, the easier and less threatening their science identity work.

In this study, we demonstrated the ways individuals were produced as certain kinds of science learners and the ways they responded and adapted to limited choices. The distressing aspect of

this story is that students' choices became increasingly limited and, over time, they were produced in ways that put distance between their scientific fourth-grade science selves and their sixth-grade selves. The uplifting part of the story is that, in a fourth-grade classroom that drew on richly woven figured worlds, allowed for multiple ways to align oneself with the celebrated subject positions, and leveraged students' social identities in service of robust science learning, they all wanted and were able to do the identity work necessary to become scientific.

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2. Thank you, Angela Johnson, for this perspective.
3. Hill (1995), cited in Holland et al. (1998), noted “how the speaking of ‘junk Spanish’ by non-Spanish speakers in the United States works to debase the speaking of Spanish, keeping it an index of lower social position” (p. 134).

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