Transforming Science Learning and Student Participation in Sixth Grade Science: A Case Study of a Low-Income, Urban, Racial Minority Classroom

By: Edna Tan and Angela Calabrese Barton

Tan, E. & Calabrese Barton, A. (2009). *Transforming Science Learning and Student Participation in Sixth Grade Science: A Case Study of a Low-Income, Urban, Racial Minority Classroom*. Equity & Excellence in Education, *43*(1), 38-55.

Abstract:

Recent criticisms of the goal of "science for all" with regard to minority students have alluded to the onerous culture of school science characterized by white, middle-class values that eschew personal everyday science experiences and nontraditional funds of knowledge, in addition to alienating science instruction. Using critically-oriented, sociocultural perspectives, this article explores the sixth grade classroom of a male, white, science teacher in an urban school that serves only minority students. Using Holland, Lachicotte, Skinner, and Cain's (2001) notion of figured worlds, we look at what learning science looks like in Mr. M's classroom and how he provides the structural support to increase student participation by creating different figured worlds of sixth grade science. In these different figured worlds, we discuss the pedagogical strategies Mr. M uses to purposefully recruit nontraditional funds of knowledge of racial minority and low-income students, thereby positioning them with more authority for participation. Through this case study of Mr. M and the racial minority and low-income students he teaches, we discuss the role science teachers play in urban school science education and the agency and achievement racial minority and low-income students are capable of with appropriate support.

Article:

There are sounds of excitement and the whirling of kitchen appliances emitting from Mr. M's sixth grade classroom at 7:20 a.m. this Friday morning. Teams of students have come in early that day to prepare for science class—the final lesson of a nutrition unit. They have brought in an impressive array of food items that run the gamut of fruits (like mangoes, cantaloupe, and raisin rice pudding) and grilled chicken kebabs with an Asian dipping sauce. At table 6, a group of students are blending milk, bananas, strawberries, and grapes into a smoothie. Another group of students assemble "cocktails" made from fruit and juice and decorate the rim of each cup with lemon and lime wedges. During the lesson, students work in teams preparing their own concoctions of healthy appetizers to share with their peers. For 30 minutes of the lesson, the students prepare food, walk around and visit their friends' tables, sample one another's appetizers, and chat about the nutritional benefits of their appetizers. One group prepared a complete breakfast consisting of whole-grain bread, turkey, and cheese sandwiches, waffles, and fruit cocktail to share with the entire class. Many teachers in the school stopped by to visit Mr. M's classroom. Both the principal and assistant principal also visit to sample the students' creations and to talk to them about their concoctions. In the last 15 minutes of the lesson, each group gives a short presentation of their appetizer with an accompanying poster that they had created to augment their contribution. Titles and slogans of these posters include such names as, "Tasty but still healthy," "Tropical fruit takes you to paradise," and "Mmmm, delicioso!" The posters hang on long "laundry lines" draped from the classroom ceiling afterwards. Both teacher and students enjoyed this lesson.

After the lesson, Mr. M opined:

> I think nutrition and food is such a major element. Students would bring up their families, cultural differences that in another setting they may be inhibited to share or talk about … And it's a moment for them to be very proud, you know … its like celebrating something, which I think, far too often, in an environment like this, they hear more negative than positive things about themselves. So I think that's also why they like science, because it's framed more … where they get their own voice.

Cindy, one of the students, proudly shared her thoughts with us, “I think in this whole entire school, I think this is the first time we did this.”

We began with this vignette on the appetizer lesson because it is a lesson where almost all the students, including those deemed by Mr. M to be students who are usually distracted and not interested in the lesson, engaged with the subject matter and participated meaningfully, with significant personal agency and effort. There was a palpable change in student engagement from other lessons, one to such a degree that warranted other teachers of the school and both principals to come to witness this scene. Many students, including those who did not do well in science, received the highest grade of level 4 for this culminating activity of the nutrition unit. Students also produced detailed nutrition guides during the study of this nutrition unit. In the nutrition guides, students showcased their understanding of science content, such as the food pyramid, sources of different food groups, as well as essential vitamins and minerals. They also showcased their personal application of such knowledge by creating a healthy menu of meals.

This lesson showed what a collective third space—where students are empowered as legitimate experts in the community with valuable resources—in a middle school science classroom could look like. It is radically different from a typical science class in the roles the students and teacher take, the science artifacts students produce, and the manner in which they engage with the science content. Student participation is grounded in the diverse communities relevant to their lives. We explore how the science teacher, Mr. M, brokered for collective third spaces in his science class with and for his students. Specifically, we pay attention to the diverse figured worlds—different spaces that allowed for various forms of student participation—he creates in his classroom that expand the entry points for students into school science. We also explore how he further encourages and empowers his students for authentic participation through particular pedagogical strategies within these various figured worlds. By sharing stories of Mr. M and his students, we hope to show explicitly, how a teacher engages in teaching science for social justice by taking an anti-deficit stance toward his students, expanding the roles they play in science class by providing ample opportunities for them to negotiate their participation, and sharing authority with students by giving them the freedom to assemble a personal science portfolio that counts toward their final grades.

THEORETICAL FRAMEWORK

Refiguring Learning and Space for Transformative Science Education

A central tenet of equity-driven research in science education is that an important role of science teachers is enculturating their students into the culture of science. Students ought to be provided with opportunities to become aware of the norms and practices of school science and to learn how they are expected to participate through discourses, ways of knowing, and practices (Aikenhead, 1996; Lee & Fradd, 1998). Enculturation has been central to the equity agenda because it makes concrete the complex challenges that many youth face as they are expected to cross borders between the “home-based cultural worlds” and the “world of school science.”

We are concerned, however, that a singular focus on enculturation—even when thoughtfully and carefully conceived to call attention to students' cultural knowledge and experience—is too narrowly focused on the discourses and practices of school science to promote a transformative science education. Enculturation neglects the selective nature of the worlds of school science and the challenges imposed upon those who do not possess the resources or the identities to be an integral part of those worlds. Further, such a stance neglects the poor alignment between heterogeneous nature of science in the world and the homogeneity imposed by school science.

By transformative learning we draw upon Freire's (1970) argument that education ought to provide opportunities to understand, challenge, and re-create understandings of the self and the world. We also draw upon critically-oriented, sociocultural studies of learning (Gutiérrez, 2008; Moje, Ciechanowski, Kramer, Ellis, Carrillo, & Collazo, 2004) that call attention to how the “spaces” for learning themselves must be transformed, allowing the re-inscription of symbols, resources, and rules that define and mark what learning looks like as well as who one must be, that is, what one must say and do, the specific ways to perform tasks, and the like, to be successful in those spaces. Such a critical orientation to the transformation of the spaces of learning is just as important for equity-minded research and teaching, for it offers a mechanism for resisting the binaries of home and school, formal and informal education, and pays attention to the “cultural dimensions of learning and development that occur when people, ideas, practices of different communities meet, collide and merge” (Gutiérrez, 2008, p. 150).

We draw upon Gutiérrez's (2008) most recent work on collective third spaces to guide our understanding of space and its role in transformative education. Gutiérrez (2008) explains that it is a “particular social environment of development [in which] students begin to reconceive who they are and what they might be able to accomplish academically and beyond” (p. 148). A collective third space allows one to examine not only how practices travel through contradictory contexts and activities but also how those practices reciprocally transform and are transformed by those communities.

A focus on a collective third space provides a new lens for understanding learning in science because it calls attention to the “horizontal dimensions” of learning. Unlike a focus on the vertical dimensions of learning, which focuses on movement from “immaturity and incompetence to maturity and competence,” horizontal notions of learning focus on expertise that develop within and across practices and communities (Gutiérrez, 2008, p. 149). In horizontal learning the focus is on both the distributive nature of learning and the repertoires of practices that individuals cultivate as they move through space and time. Gutiérrez's point is particularly important because little attention outside of equity-driven research has focused on how learning is informed and transformed by the sociopolitical dimensions that shape everyday activity and living, or in Guterriez's words, “how poverty, discrimination, exploitation, anti-immigrant sentiment, language ideologies, and educational and social policies gone awry complicate current understandings in the learning sciences about learning and development” (p. 149). This point is particularly salient to science learning, as the culture of canonical science has been characterized as alienating to racial minority students, given its male, white characteristics (Aikenhead, 1996; Aikenhead & Jegede, 1999; Fordham, 1993) Further, minority students' struggles to gain full access to school science are often misinterpreted as their lack of aptitude in science (Gilbert & Yerrick, 2001).

Using the framing lens of a collective third space challenges how we capture a moment in words or images and think about the sociocultural-physical space of the science classroom as well as how that space mediates learning. One way to attend to this is to think about the “figured worlds” (p. 49) and “identities-in-practice” (p. 271) that such collective third spaces are built upon and also make possible (Holland et al., 2001).

Figured worlds are stable and shared “realm[s] of interpretation in which a particular set of characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others” (Holland, Lachicotte, Skinner, & Cain, 2001, p. 52). As historical phenomena, figured worlds act as “traditions” offering form and meaning to our lives. But as socially organized and reproduced phenomena, they are also “webs of meaning” where activities, discourses, performances, and artifacts are coproduced over time, and where our senses of self are often “divided” and “distributed” across many different fields of activity (p. 51).

On initial entry into a figured world, novices gain social positions that are accorded by the established members of that world. Such “positional identities” (Holland et al., 2001, p. 125) are inextricably entangled with power, status, and rank. As students engage in science in their classroom, they acquire certain identities that are related to who they are—salient identities important to them at that point in time—and who they want to be, that is, possible future selves, as they engage in this community of practice. Learning science is thus manifested through the transformation of “identity-in-practice” in the science classroom. Identities-in-practice in the context of this research, therefore, refer to the identities students acquire or choose to adopt in the science classroom.

Urrieta (2007) reminds us that the construction of particular kinds of figured worlds allows for both the transformation of how people conceptualize who they are and want to be as well as how that figured world takes shape over time. He writes:

> Through participation in figured worlds people can reconceptualize who they are, or shift who they understand themselves to be, as individuals or members of collectives. Through this figuring, individuals also come to understand their ability to craft their future participation, or agency, in and across figured worlds. (p. 120)

These "as if" worlds are created and sustained by how people figure themselves within them. These worlds offer new and different possibilities for how people work to figure themselves (i.e., trying out new identities that can help transform contexts) and be figured (i.e., how contexts themselves transform identities). We view those "moments" of transformation—of self and of space—as the collective third space that Gutiérrez (2008) writes about.

In our own research, we show how Mr. M, by creating different figured worlds within sixth grade science, expanded the repertoire of identities that students could legitimately author in science. The various figured worlds also attenuate the dominant power hierarchy that is often present in the formal science classroom, with the teacher ranked as the master practitioner, followed by target students[1] known for their epistemic knowledge. A variety of figured worlds offer fresh backdrops against which more students can be positioned with authority as nontraditional resources and funds of knowledge (Gonzalez, Moll, & Amanti, 2005) are highlighted and valued.

METHODOLOGY

Data Collection

The methodology used for this research study is in the tradition of ethnographic case studies. We were in Mr. M's classroom at least three times a week through two academic years. Data collection methods included field notes from participant observation, video footage of science lessons, and 20 semi-structured interviews with Mr. M and focus group students. Each focus group interview consisted of no more than five students at one time. As a participant observer, the first author, Edna Tan, took on various roles, such as the teacher's assistant in helping him get materials ready for the lesson or sometimes co-teaching the class. This also gave the students access to more than one teacher and more opportunities to ask questions. Field notes taken during these sessions complemented the video footage of the whole class and helped create a more detailed description of the proceedings in the science classroom. Each week, we also had informal meetings with Mr. M to share our observations as well as to brainstorm ideas for the lessons. Mr. M thus provided the project with constant member checking (Creswell, 1998).

Research Setting

The Inquiry School (TIS) where Mr. M taught is situated in a poor neighborhood in a large Northeastern city. TIS is a new, large, K-8 school that has 910 students (45% of whom are African American, 55% of whom are Hispanic, and with 90% of the students on the free lunch program). TIS is set up on the premises of a failing (did not meet the standards of the city's Department of Education in terms of test scores) school. The school has a science focus: Each class of students gets five 45-minute periods of science each week.

Mr. M is an Irish, Italian American in his early 30s who grew up in the same city with five years of teaching experience in urban settings. In all his science classes during our 2-year collaboration, Mr. M was the only white, EuroAmerican person in his classes of minority students. With admirable classroom management skills, he had very strict expectations for his students in the distinct segments built into a 45-minute lesson. For example, during the first seven minutes of the lesson, students were expected to enter the classroom quietly, go to their seats, put away any material not related to science in the baskets under their chairs, and answer the “Do Now” question silently in their science notebooks. Mr. M also had strict rules as to when students could ask questions—only when he said he was taking questions and only if they sat quietly with their hands raised and waited for their turn. These descriptions may paint the picture of a rigid disciplinarian who instills respect and possibly fear in students, but Mr. M is the most beloved teacher in his school. Almost all the sixth graders cite Mr. M as their favorite teacher and science as their favorite subject. Due to his admirable classroom management and relational ties with many of his students, Mr. M is regarded as the resident “expert-teacher” with whom other teachers consult and admire.

Mr. M was someone who, while a rigid disciplinarian, cared deeply about his students, worked to understand their lives, and used that understanding in his teaching. He told us:

> I think most of the students that I teach, you know, have value, and you know they shouldn't just be cast aside. And if I give them an opportunity and a safe environment, they'll rise to the challenge … It is, it's them feeling comfortable and not being intimidated and frightened. I think it all goes back to, just, them sensing that what you're trying to do for them is valuable, where it's not abstract and unusable … [Also], you don't know why they are in this [high poverty, urban] environment, but it doesn't mean that they aren't as intelligent and motivated.

Data Analysis

We looked at how students engaged with science in the different figured worlds in Mr. M's classroom, how he facilitated student engagement, and the learning outcomes for specific students as well as for the community. Possible links between particular contexts in the community and student manifested identities-in-practice (Holland et al., 2001) were explored, as were potential changes in students' identities-in-practice, both spatially (in the different figured worlds) and temporally (as the school year progressed). As analytic themes emerged, axial and selective coding were then undertaken. We used constant comparative analysis (Glasser & Strauss, 1967; Strauss, 1987; Strauss & Corbin, 1990) in the tradition of grounded theory for data analysis, guided by our research questions. Data were triangulated through the different methods used in collection (e.g., fieldnotes, video-footage, and interviews with students and Mr. M).

FINDINGS

Introducing Mr. M's Sixth Grade Science Classroom

Mr. M's science classroom was a popular space among the sixth graders. Many students visited his classroom in the early morning before school officially started rather than report directly to their first period classrooms. Six to eight team tables were set up in Mr. M's classroom. Laundry lines suspended from the ceiling displayed student work that almost always involved an art component in addition to text. There was a word wall above the blackboard where Mr. M posted “key terms” (e.g., calories, calcium, carbohydrates) related to the unit of study. Science charts (e.g., plant pollination and germination cycles, types of trees, human respiratory system) adorned the walls. There were also three-dimensional scientific models of cells, a human torso with removable organs, and a full-sized model human skeleton. Live animals also shared the classroom space. A menagerie of class pets included dwarf hamsters, frogs, fish, snakes, and a praying mantis. There was also a plant growth station with fluorescent lamps, aluminum trays, potting mix, and receptacles where students grew and monitored plant growth.

Mr. M used the physical, intellectual, and relational space of his classroom in dynamic ways, each of which contributed to how and why students have opportunities to engage more deeply in his science class. In the formal space of the classroom, Mr. M made use of whole class discussions, presentations, small group work, and individual work as his main strategies for engaging students. For example, Mr. M grouped his students into teams that sit around a large team table, each with an appointed team leader. Mr. M rearranged the room so that teams were smaller to give each student more ownership and responsibility for any given team task. Mr. M also rotated the students so they got to work with different classmates for a few weeks at a time. Students were grouped strategically to encourage collaboration and camaraderie, where team members looked out for and encouraged one another's participation.

However, we also noted that during a whole class discussion, Mr. M had strict rules and expectations for student participation. Students were to raise their hands and remain quiet until he called on them. When a student was speaking, all other students were expected to have their “eyes and ears” on the speaker. Interruptions were dealt with swiftly and effectively, with Mr. M stressing the importance of “respecting the speaker.” As a result, a student speaker was heard most of the time by all her or his peers whenever something was shared. In this way, Mr. M safeguarded the participation space of each student.

Mr. M also crafted informal spaces to encourage more students to engage in science. For example, Mr. M invited students to come to his classroom before and after school or during lunch to help clean up or to care for the class pets. Using grant money, he took his students on once-a-month, Saturday fieldtrips with their families to engage them in science around the city. Parents and students went with teachers, including Mr. M, to botanical gardens and the zoo, and on fishing trips, overnight camping trips, and overnight visits to a science museum and planetarium. These informal spaces gave students who are quieter and less inclined to speak in front of their peers in the formal classroom an opportunity to interact with their teacher and science-related tasks in a less intimidating context. By entering into a relationship with science through these informal spaces, students can potentially develop a sense of ownership and an identity with science that is not necessarily grounded in test scores and content mastery.

The Figured Worlds of Mr. M's Sixth Grade Science Class

Science class, as a “socially and culturally constructed realm of interpretation” (Holland et al., 2001, p. 53) represents one potential figured world. Yet what happens in science class changes from day to day, from moment to moment, from classroom to classroom, and across schools and districts. Moments in science class are culturally constructed, and participants, including teachers and students, play socially ascribed roles (Holland et al., 2001). These roles are mediated by the histories that teachers and students bring to science class, allowing locally situated meanings to be co-constructed within these figured worlds and giving new form and meaning to the worlds that make up science class. We can therefore view the figured world of science class as comprising the historical phenomena that reproduce life in science classrooms alongside the individual actors who shape and re-shape both themselves and their figured world by the ways in which they choose to participate in an event, such as making and sharing healthy appetizers.

Mr. M's teaching—his practices, his construction of the physical space, and his interactions with his students—forged at least three emergent figured worlds that supported students in gaining entry and authority in science by storytelling, by being real, and by engaging in diverse, authentic science-based participation. Each of these figured worlds is described below with the help of an extended exemplar.

Science Class as a Figured World of Storytelling

Storytelling is a practice that Mr. M regularly used to create a range of entry points for his students in science class. Both Mr. M and his students regularly used stories to ask questions, to expand points, to challenge ideas, and simply to “gain access” to a conversation. This figured world cuts across the whole class and small group spaces and positions students as epistemic experts by virtue of their ability to build canonical arguments through everyday experience and discourse.

Storytelling has two critical aspects. First, the storyline or the substance of the story focuses on the ideas of science. Although substance is important, for without it we have no narrative, stories are reflexively shaped by style, by the teller, and by the audience's participation and response. One way to consider this is to think about how stories imply storytelling. Storytelling, according to Miller, Cho, and Bracey (2005) is a “cultural tool” imbued with “ways of seeing” and knowing that “privilege certain slants on experience” (p. 115). Storytelling positions the author with the situated authority to make claims about what is real and true in the world and to background and foreground how those truth claims are situated by time and place and culture. We use the frame of the figured world of storytelling because when storytelling was invoked or invited as an explicit and essential part of science class, it called to the center particular resources and discourses that are often on the fringes of a science classroom.

We share the following to develop the nuanced and powerful dimension of the storytelling figured world Mr. M created. The following transcript is taken from a whole class discussion during a lesson on skin anatomy:

Chantelle: Mr. M …
Mr. M: Eyes and ears on, Chantelle!
Chantelle: Um, I heard that my friend, um, he's, he's real light.
Mr. M: Lighter than me? Ok …
Chantelle: [nods] Lighter, like, almost like Kim. And he has skin cancer cause he can't be in the sun.
Mr. M: Good point. The sun is so powerful, light skin people can actually get skin cancer. The cells in your skin can mutate, and that's what cancer is. Mutated cells. Phil, what does Michael Jackson have, above his head, all the time when he's outside?
Melanie: Umbrella! An umbrella!
Mr. M: Who's walking around behind Michael Jackson now?
Joey: Security!
Mark: Can I say something? I don't I don't, I don't really understand that because Michael Jackson's really black.
Mr. M: He bleached his skin. And now, you see him in the news, someone's always behind him carrying a what?
Class: Umbrella!
Mr. M: Why? He doesn't want to get what?
Melanie: Darker!
Mr. M: So what does he prevent hitting his skin?
Class: The sun!
Mr. M: So his body's not making what?
Melanie: Protect-
Class: Melanin!

In this transcript, we see that the students readily brought their personal experiences into a science class discussion. Mr. M encouraged student voice by engaging with Chantelle in her story when he used himself as a reference point. He then linked Chantelle's sharing to the science content of skin anatomy and skin cancer. In addition, Mr. M brought up the pop star, Michael Jackson. Within this lesson, Mr. M allowed and protected Chantelle's space to share her story about her friend. He also skillfully took up her story about the greater risk light-skinned people have of developing skin cancer by bringing in relevant news from popular culture. Michael Jackson was a public figure with whom most students were familiar. He was also a character one rarely invokes in a science classroom. By bringing Michael Jackson into a whole class science conversation, Mr. M signifies and models for his students that nontraditional funds of knowledge are acceptable resources in his classroom discourse. He then uses student responses from Mark and Melanie to further discuss the Michael Jackson example and bring the discussion back to science content. With this short example, Mr. M shows that he also shares an identity with the students as a consumer of popular culture, that popular culture and science are not necessarily at odds, and that student stories are legitimate contributions to classroom discourse.

Science Class as a Figured World of Being Real

Mr. M uses a range of pedagogical approaches to craft figured worlds in his classroom that reflect the "real world" more so than school does. We view a second figured world that was often enacted in his classroom as that of "youth-based reality," which is comprised of discourses and practices that dominate youth's out-of-school experiences and activate epistemic knowledge that is rooted in such experience. While the term "real" connotes that somehow these worlds are more authentic than the figured worlds that make up school, we do not think this is the case per se; rather, we have opted to use this term to suggest an authenticity regarding who one must be to engage in that world, breaking down the artificial barrier between home and school. To highlight this world we share how Mr. M. engaged his students in debating the merits of smoking within the context of a series of units on the respiratory system.

After teaching the students about the respiratory system, Mr. M wanted to increase student participation by having each team write and enact a short skit with an anti-smoking theme. In the skits, community-based funds of knowledge, grounded in the students' lives in their neighborhood took center stage, providing the plotlines of several skits. Street culture and ways of speech are also showcased in many skits and students' everyday lives in their neighborhood became the core content of science class. An example of the dialogue in such a skit follows:

> [Chantelle holds up a sign that says "In a corner" to set the scene.]
> Chantelle: [saunters in holding imaginary newspapers] Newport! Newport! Newport! Who wants Newport?
> Tricia: [saunters up to C with enthusiasm and the two greet with elaborate hand shaking ritual] HEY CHANTELLE! How you doing GIRL?!!
> Chantelle: Whassup whassup whassup?! [while engaging in hand ritual with Tricia]
> Tricia: This is my friend, this is Lionel, that's Tom … [gestures to both boys]
> Chantelle: Whassup whassup whassup … [grips the hands of both boys in turn as if to arm wrestle] You guys wanna smoke? [holds up bunch of imaginary cigarettes]
> Tricia: Yeah!
> [Chantelle hands out imaginary cigarette to Tricia, Lionel, and Tom and mimes lighting each cigarette; Tom throws his cigarette to the floor.]
> Chantelle: [to Tom] Why you don't wanna smoke? You a wussy?
> Tricia: You're a WUSSY!!!
> Chantelle: Get out of here, get out of here! [pushes Tom away] You're wasting my money, get out of here man!
> Tricia: Yeah, we don't want you!
> [Tom tries to get Lionel and Tricia to leave with him but was unsuccessful. Tom leaves. Chantelle turns her attention to Lionel and Tricia as they continue "smoking."]
> Chantelle: Yeah yeah yeah, so whassup whassup whassup …
> [Lionel starts to cough violently while "smoking."]
> Chantelle: [pats Lionel on the back] Yo yo yo!!! That's not how you do it, yo, that's not how you do it! Slowly, softly, softly … [gestures to Lionel]

The skit ends with Tom coming back and inviting everyone to his house where he showed them from the internet the biological consequences of smoking, and the smokers were all shocked and "going into rehab."

In the skit, Chantelle appears as a girl selling the "Newport" newspaper (instead of being in school). She is friends with Tricia, who attends school with Lionel and Tom. By having Chantelle portray a youth who works, the students alluded to having contact with working youth with concerns very different from school but who are no less important in the students' lives. In the skit, Chantelle's character not only works by selling newspapers but is also a young smoker who is keen to introduce her school-going friends to smoking. The language and body gestures enacted also illustrated the unique code of conduct that is part of the street culture among youth in this specific neighborhood. Peer pressure featured largely in the skit along with the painful consequence of public humiliation with disparaging name-calling and outright rejection should a youth choose to go against the crowd. The four student actors convincingly showed the realistic and tough side of urban living and the acute force of peer influence. As Chantelle's character alluded, taking up smoking from peers can be made desirable when a youth is faced with choosing between suffering social pressure and gaining acceptance through free cigarettes and guidance from the tutelage of expert friends who can coach one to inhale the first puffs of smoke "slowly" and "softly."

Mr. M asked the audience for feedback, and some students shared their own experiences in struggling against peer pressure. Another student pointed out a local grocery store that would not hesitate to sell cigarettes to minors. Instead of concentrating solely on emphysema and carcinogenic ingredients in cigarette smoke, the class talked about how smoking was prevalent among their peers and discussed the options open to them. Mr. M facilitated the discussion with sensitivity and thoughtfulness, reminding the students what they have learned to reinforce the message on the dangers of smoking as well as suggesting ways students could deflect peer pressure. In so doing, Mr. M made clear that the students' out of school lives, their community funds, and out-of-school discourse were welcome in his classroom space. The sixth grade community-of-practice as a whole inhabit a collective third space where a new classroom discourse is created through the integration of students' community funds and discourse with the disciplinary texts and discourse of school science. The students not only participate as learners of school science—learning the physiological consequences of smoking—but also engage as expert informed citizens around the localized context of student experiences with the issue of smoking and how they can merge scientific knowledge with community knowledge to be more empowered and critical in the issue of teen smoking in their neighborhood.

Science Class as a Figured World for Diverse, Authentic, Science-Based Participation

Mr. M invites his students to take up a range of positions in his classroom other than that of a traditional student. They are pet caretakers, plant caretakers, teacher helpers, and student leaders. By providing students with a wide repertoire of science-based identities, Mr. M affords students with a range of entry points into school science and with him, the science teacher—access that need not be bartered for solely by epistemic science knowledge. Students can build relational authority with Mr. M and be engaged with science without having to be positioned as a traditional "good science student." For example, students from each class volunteered and asked to be either an animal or plant caretaker. Mr. M usually has each applicant write a short paragraph explaining why she or he would be good at this "job" and the students thus went through a selection process. After they have been selected, certificates are printed out and put on the wall where the class pets were housed. Therefore, there is a certain level of prestige and recognition given to selected pet and plant caregivers. These students then had permission to enter the science classroom and to interact with Mr. M outside of class time. They often popped into class early in the morning before the first bell, during lunch, or after school. They discuss animal and plant care with Mr. M, work with him to keep the animals clean, and accompany him to the pet store across the street to get supplies. We found that gaining expertise in these informal spaces and building a relationship with Mr. M often translated into students being better positioned to participate more centrally in the formal science lessons (see Tan & Calabrese Barton, 2008). Table 1 summarizes the pedagogical strategies Mr. M enacts to tap into the nontraditional resources in creating these figured worlds.

TABLE 1 The Figured Worlds and Pedagogical Strategies in Mr. M's Sixth Grade Science Class

Figured World	Pedagogical Strategies	Nontraditional Funds of Knowledge and Resources Recruited
Story-Telling	• Increasing student voice by soliciting student stories and out of school funds of knowledge • Enforcing audience roles and responsibilities so as to safeguard participatory space of presenter • Sharing his own personal life and experiences as an example	• Student's lived experiences from home, traveling, in their neighborbood • Mr. M's out of school life • Student interest and talent in art, popular media, drama

TABLE 1 The Figured Worlds and Pedagogical Strategies in Mr. M's Sixth Grade Science Class

Figured World	Pedagogical Strategies	Nontraditional Funds of Knowledge and Resources Recruited
Being Real	• Increasing student voice by soliciting for student stories and out of school funds of knowledge	
	• Incorporating drama/skits as a platform to discuss science and students' lives	
Authentic, Science-Based Participation	• Valuing and highlighting student-centered artifacts	• Teacher insight into particular needs of students
	• Tailoring specific modes of participation according to needs of particular students	• Relational authority between student and teacher
	• Creating a space for less prominent students to gain ownership, authority and agency in science through taking on the roles and responsibilities of caretakers of pets and plants	• Relational authority between parents and teacher
	• Engaging with students and their parents who sign up for the fieldtrips and after school science club. Mr. M leads the fieldtrips himself with the small number of students who participate, yielding both students and teacher time and space to build relationships outside of the classroom.	
	• In the after school science club, which is also open to parents, Mr. M conducts activities, such as squid dissections, to acquaint parents with what their students have been learning in class.	

DISCUSSION

Building Collective Third Spaces Within and Across Figured Worlds to Position Students with Authority

Across the vignettes we can see how Mr. M's teaching allows for the emergence of a range of figured worlds in his classroom. These figured worlds afford students with more possibilities in terms of the funds of knowledge and discourses legitimated and valued for participation, thereby broadening the criteria of whom one can be to engage deeply in science. Mr. M's students have the opportunity to engage in different figured worlds, each of which offers them unique platforms for participation. Thus far we have discussed the figured worlds of Mr. M's classroom as if they somehow stand distinct from one another. However, figured worlds are dynamic, shifting as the individuals within them activate new resources and identities and assert themselves in novel ways. Furthermore, as classroom activities shift, new figured worlds can be invoked, thereby repositioning students and teacher as activity moves forward.

We also think that Mr. M's ability to encourage fluidity among figured worlds through his teaching practice plays a pivotal role in determining learning outcomes and the subsequent participation of individual students. For example, apart from taking notes in the classroom, learning key terms, and working on science worksheets (activities that are archetypal of the figured world of traditional school science), Mr. M provided each student with a science portfolio where students could elect to showcase pieces of work with which they were especially satisfied. By doing so, Mr. M raises student autonomy and shares his authority with students in a very concrete way through soliciting student input, not only for what counts toward their final science grade but also for how they want to be represented as a science student. The students exercise some independence in creating and selecting science artifacts of their choice, which are counted toward their final grade in the portfolio.

For their response to these Science Times articles, students had to reflect on whom the article was written, the issues that were discussed, what aspects of science resonated with the students, and why they chose the article. Shila had chosen a Science Times (a section from the *New York Times* newspaper) article response she had written as one of her portfolio pieces. The Science Times article she chose focused on the training routine and injuries of the American Olympic figure skater, Michelle Kwan. She shared her Science Times response in class and later included it in her portfolio.

> I feel very happy [about the portfolio] cause … this is like, this portfolio has all this work I've done through science … it has like, all my effort in there and stuff so, its like kinda real exciting cause I have my work in there that I can show my parents that I've done and that I can show my teachers when they promote me to the seventh grade. I hope [people who look at my portfolio] will think that I'm a super short scientist, cause since I learned a lot about science and show all my work here … it'll make me look kinda good cause if I don't have anything here people will say, wow, why should I promote her to the 7th grade. … My portfolio is based on MY life. It's like the portfolio that I have created with all my ideas and with all my imagination.

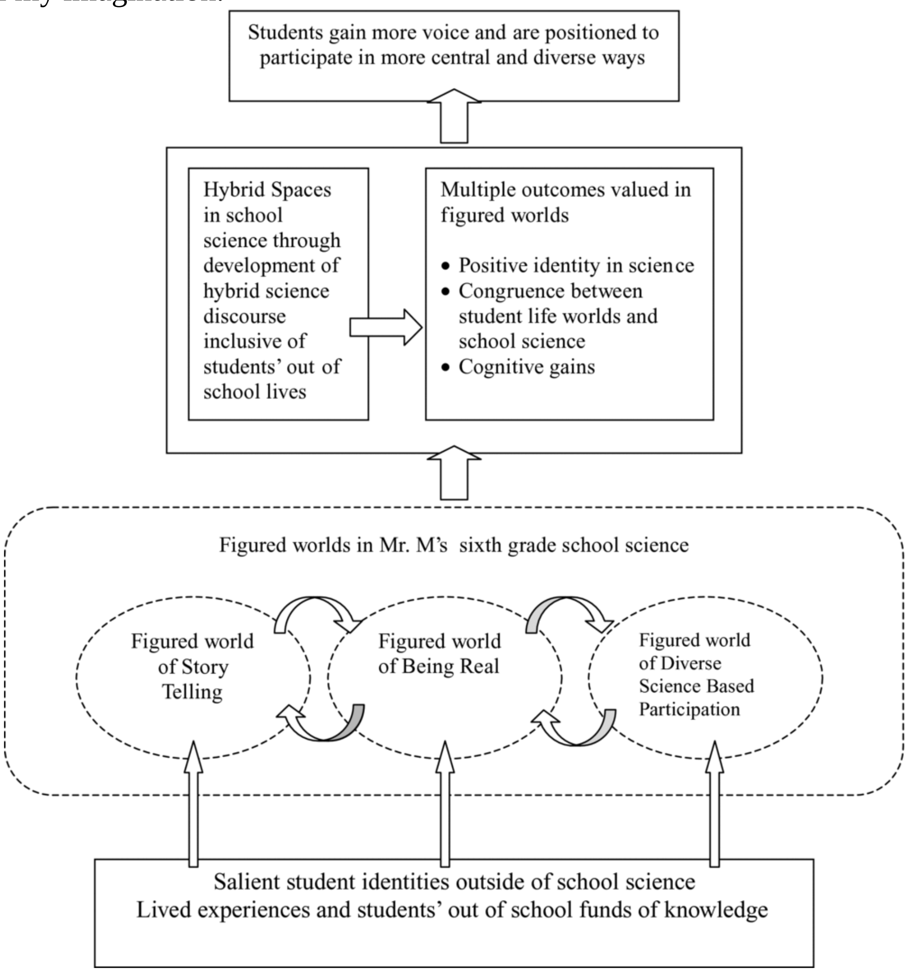

FIGURE 1 Multiple figured worlds and fluidity across figured worlds increase student voice and support diverse forms of participation

Another student, Cindy, also said that her portfolio allowed her to show that she "loves science" and "knows about more science" than can be revealed in a pen and paper test. Cindy pointed out that classroom tests are usually narrowly construed and focus on a small percentage of the science knowledge that students have learned. Therefore, to her, doing poorly on a test does not necessarily make one a bad science student. A portfolio allows for a more holistic assessment of a student's ability in science. The portfolio also validates the talents and interests of students as important resources in science class and highlights student individuality (e.g., present through drawing and graphics instead of giving a speech) and identity as legitimate and significant outcomes of science learning. The portfolio is a tool that allows students to experience personal achievement in science in a positive and empowering manner that is congruent with salient aspects of their lives. In short, the portfolio provides both Mr. M and the students with another way to make sense of their school science participation and achievement.

These diverse ways in which students engage in learning highlight how Mr. M uses a range of figured worlds to value multiple outcomes in his classroom in addition to content mastery. Other outcomes valued by Mr. M include: student enjoyment in and developing a positive identity in science, increasing student agency, and strengthening the congruence between school science and students' lives so that students are positioned with more authority in school science (see Figure 1). We argue that any cognitive gains made by students are enhanced through the valuing of multiple outcomes. These outcomes are possible only when the other components that demarcate the activities in his classroom are equally diverse.

Mr. M's various figured worlds create a dynamic environment for students to engage in science learning from positions of authority. Participating in science class is risky for many students because it often requires them to take up identities or practices that are outside their everyday experience, leaving them little room to access or activate the resources they bring to learning. Creating different figured worlds in a science classroom that allow a broader range of funds of knowledge and discourses potentially opens different routes for students to gain authority in science.

We further posit that the multiple figured worlds created by Mr. M allow for student authority because they allow for collective third spaces for participation to emerge. Take, for example, the anti-smoking skit. On first glance, this skit seemed to be more about “a day in the lives of urban youth” than a skit centered on scientific concepts. However, it is precisely because it is so grounded in community funds and discourse that a collective third space was fostered both in its enactment and in the class discussion that ensued. These collective third spaces are important because they bring together the different knowledges, discourses, contexts, and relationships one encounters in ways that collapse “oppositional binaries,” allowing them to “work together” to generate new knowledge, discourses, and identities (Moje et al., 2004, p. 42). They “disrupt” normative rules, roles, and tools for mediating participation in a community of practice. Science becomes a relevant context in addition to being a goal, and this science context is powerful precisely because students experience it as a reality in their everyday lives with the attendant identities germane to them. The students' street discourse, with its attending valences of power, are dramatically woven into science classroom discourse. The audience gave these four actors riotous applause and showed their appreciation with calls of, “That's cool.” They related to the skit throughout its enactment, laughing at Chantelle's antics but falling silent in those moments when Tom was ostracized, suggesting that they empathized with his situation despite its being only an act. It was an act that mirrored personal experiences, and those personal experiences were a valid presence in their science classroom.

These collective third spaces are platforms where more equitable science opportunities are afforded to Mr. M's students in a high poverty, urban school. Importantly, it is in these collective third spaces where Mr. M empowers students to take on, however momentarily, the authorial identity of an “expert” rather than a “novice,” where they experience validation for their contributions. This process is facilitated by Mr. M's explicit invitation of student's salient identities grounded in their out-of-school communities in addition to their identities-in-practice in his science classroom. By diversifying the number of communities that can be represented in a science classroom, Mr. M effectively broadens the legitimate number of roles and entry points accessible to students in his science class. These widened entry points work to sanction student's nontraditional funds of knowledge and to highlight the connection between science and their everyday lives.

By drawing from and validating such nontraditional funds of knowledge (e.g., popular culture, personal experiences, counting the science portfolio toward student assessment), Mr. M engages in anti-oppressive science teaching. As the teacher, Mr. M learns where his students were coming from, building on their own out-of-school proficiencies, and making connections between students' existent knowledge and what they need to learn in science class. Mr. M diverges from the familiar path of teaching science in a common sense way—

where “the foundations have become 'obvious' and disappeared from view; one is able to take the basic axioms for granted and use them correctly and unselfconsciously” (Shulman, 1996, p. 449) in a repetitive, clinical manner of “doing science.” Such a view of teaching and doing science is based on the canonical definition of science, which is grounded in patriarchal and Eurocentric values. Kumashiro (2001) reminds us that “teaching in commonsense ways cannot help but maintain social inequities” (p. 9). Collective third space teaching and learning therefore allows for a new hybrid discourse of school science that draws from both canonical science (e.g., the skin lesson) as well as students' funds of knowledge in ways that are empowering for the student and which positions them to engage more deeply with school science in ways that augur well for students' school science trajectories.

Furthermore, building relational ties with his students by engaging with them in the informal figured worlds allows Mr. M to get to know students individually. He has empathy for his students and is well acquainted with their lives outside of the classroom. By inviting student stories, he equips himself with specific knowledge pertaining to the challenges his students face when they leave his classroom and how those issues do not melt away when they enter or exit science class. Having this awareness is crucial because it is what impels Mr. M to have the educational goal of making science valuable to his students. Having a fuller understanding of the lives of his students also allows him to be cognizant of the complexities surrounding “problematic students” and “low achieving students.” Such awareness allows Mr. M to take an anti-deficit perspective toward the potential of his urban students and to foster ways of allowing for student agency and student voice in his classroom. Paradoxically, having such knowledge also serves to remind Mr. M that there is always an element of “unknowability” (Ellsworth, 1997) with regard to teaching his students because their social worlds—the different communities in which students participate—are not confined to what he sees in the classroom, as students are simultaneously members of figured worlds out of the school. Being cognizant of such “unknowability” guards against rigidity or teacher assumptions that may hinder student learning.

Engaging in his anti-oppressive pedagogical strategies allows Mr. M to model for his students that passion and enjoyment are integral components of learning and doing science. The students understand and follow his strict foundational classroom rules, but they also feel empowered in the figured worlds he set up for them to take risks and to share their opinions and personal stories. The assorted formal and informal figured worlds represent varying degrees of risk for students and so proffer for them many opportunities and platforms to participate at a level where they feel more empowered. With his strategies and in-depth understanding of his students through engaging with them in different figured worlds, Mr. M is well positioned, as the findings have shown, to gently but firmly challenge his students toward deeper and more public participation. Seeking out those educative settings that can steadily build positive identities-in-practice is therefore essential for these students who may struggle more with classroom structure and dynamics than with the discipline of science itself. Such struggles often are mistaken for a lack of aptitude for science and students self-censor the development of their scientific identity at the impasse of such classroom structural demands. Teacher decisions as to seemingly mundane issues, such as seating arrangements and whether to allow students to take a lesson “off track” through sharing personal stories, can be crucial for supporting or hindering student learning and development. This has implications for how figured worlds in school science are set up to encourage and nurture student authoring of science-positive identities-in-practice. Such teacher decisions also have implications for whether the science community of practice as a whole, teachers and students included, can collectively broker for collective third spaces in the science classroom that are more democratic and supportive of students' voices and diverse forms of participation.

Notes

This material is based upon work supported by the National Science Foundation under Grant No. 0652559. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

1. By “target students,” we refer to the students whom the teacher usually relies on to give the answer the teacher is looking for.

REFERENCES

1. Aikenhead, G. S. (1996) Science education: Border crossing into the subculture of science. *Studies in Science Education* 27 , pp. 1-52.

- 2. Aikenhead, G. S. and Jegede, O. J. (1999) Cross-cultural science education: A cognitive education of a cultural phenomenon. *Journal of Research in Science Teaching* 36:3 , pp. 269-287.
- 3. Creswell, J. W. (1998) *Qualitative inquiry and research design* Sage , London
- 4. Ellsworth, E. (1997) *Teaching positions: Difference, pedagogy, and the power of address* Teachers College Press , New York
- 5. Fordham, S. (1993) “Those loud black girls”: (Black) women, silence, and gender “passing” in the academy. *Anthropology and Education Quarterly* 24:1 , pp. 3-32.
- 6. Freire, P. (1970) *Pedagogy of the oppressed* Continuum , New York
- 7. Gilbert, A. and Yerrick, R. (2001) Same school, separate worlds: A sociocultural study of identity, resistance, and negotiation in a rural, lower track science classroom. *Journal of Research in Science Teaching* 38:5 , pp. 574-598.
- 8. Glasser, B. and Strauss, A. (1967) *The discovery of grounded theory: Strategies for qualitative research* Aldine , New York
- 9. Gonzalez, N. , Moll, L. C. and Amanti, C. (eds) (2005) *Funds of knowledge: Theorizing practices in households, communities, and classrooms* Erlbaum , Mahwah, NJ
- 10. Gutiérrez, K. D. (2008) Developing a sociocritical literacy in the third space. *Reading Research Quarterly* 43:2 , pp. 148-164.
- 11. Holland, D. , Lachicotte, W. , Skinner, D. and Cain, C. (2001) *Identity and agency in cultural worlds* Harvard University Press , Cambridge, MA
- 12. Kumashiro, K. (2001) “Posts” perspectives on anti-oppressive education in social studies, English, mathematics, and science classrooms. *Educational Researcher* 30:3 , pp. 3-12.
- 13. Lee, O. and Fradd, S. H. (1998) Science for all, including students from non-English-language backgrounds. *Educational Researcher* 27:4 , pp. 12-21. 14.
- 14. Miller, P. J. , Cho, G. E. and Bracey, J. (2005) Working-class children's experience through the prism of personal storytelling. *Human Development* 48:3 , pp. 115-135.
- 15. Moje, E. B. , Ciechanowski, K. M. , Kramer, K. , Ellis, L. , Carrillo, R. and Collazo, T. (2004) Working toward third space in content area literacy: An examination of everyday funds of knowledge and discourse. *Reading Research Quarterly* 39:1 , pp. 38-70.
- 16. Shulman, B. (1996) What if we change our axioms? A feminist inquiry into the foundations of mathematics. *Configurations* 4:3 , pp. 427-451.
- 17. Strauss, A. (1987) *Qualitative analysis for social scientists* Cambridge University Press , Cambridge, UK
- 18. Strauss, A. and Corbin, J. (1990) *Basis of qualitative research: Grounded theory procedures and techniques* Sage , Newbury Park, CA
- 19. Tan, E. and Calabrese Barton, A. (2008) From peripheral to central, the story of Melanie's metamorphosis. *Science Education* 92:4 , pp. 567-590.
- 20. Urrieta, L. (2007) Identity production in figured worlds: How some Mexican Americans become Chicana/o activist educators. *The Urban Review* 39:2 , pp. 117-144.