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ORIGINAL PAPER

Learning environments at the margin: Case studies of disenfranchised youth doing science in an aquarium and an after-school program

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Abstract In this article, we explore how two informal educational contexts—an aquarium and an after-school science program—enabled disenfranchised learners to adopt an identity as insiders to the world of science. We tell the stories of four youth, relating what doing science meant to them and how they positioned themselves in relation to science. We contribute to the extensive literature on the value of learning beyond the school walls, yet focus on ethnically and linguistically diverse youth from low-income backgrounds who have often been excluded from such settings. We suggest that such out-of-school settings are particularly important to youth who have few other opportunities to interact with and relate to science in positive ways.

Keywords Disenfranchised youth · Informal science learning · Learning and identity · Qualitative case studies · Sociocultural-historical theory

Introduction

Much has been written about science learning environments outside the classroom in settings such as museums, aquariums and after-school and youth programs. Beyond being linked to improvement in academic standing, participation has shown increases in science literacy, interest, positive attitudes and confidence in science, as well as higher chances of pursuing career trajectories within the sciences (Atwater et al. 1999; Fadigan and Hammrich 2004; Falk and Dierking 2000; Hofstein et al. 1990; Nicholson et al. 1994). Similarly, university-based outreach science programs show positive outcomes in terms of

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students' understanding of the nature of science and scientific inquiry, while also opening up participants' eyes to science career possibilities (Atwater et al. 1999; Bell et al. 2003; Bouillion and Gomez 2001; Richmond and Kurth 1999). After-school science programs for girls have also been found to be effective for improving self-confidence and interest in science, while also positively impacting girls' limited view of women's roles within science (Campbell and Steinbrueck 1996; Ferreira 2002).

Most effective out-of-school science programs also focus on youth development rather than science literacy per se (Delgado 2002). By youth development, we mean focusing on the full student, rather than only on content. Hence, youth's feelings, dreams and imaginations are encouraged, supported and legitimised by a caring staff who respect youth for who they are. Participants are also offered the opportunity to 'co-opt' science, making it valuable and relevant to their lives (Calabrese Barton 2003; Heath and McLaughlin 1996). Not surprisingly, such youth development settings often make science accessible to youth and families otherwise struggling with the many social incongruities of the educational system (Lee et al. 1995).

While such research has allowed us to separate the study of science literacy from "constraining assumptions about traditional institutional arrangements and hegemonic definitions of what counts as 'learning'" (Bekerman et al. 2006, p. 1), most studies have focused on academically strong students who are already serious about a scientific career, and who face few obstacles of access to science (Bell et al. 2003). Yet, we know that the same opportunities in science are particularly crucial for ethnically and linguistically diverse youth from low-income backgrounds who rarely see themselves as insiders to that world (Jones 1997; Sosniak 1995). We know, too, that out-of-school programs can become powerful resources for recruiting under-represented students into science careers and higher education (Atwater et al. 1999). Such research suggests that we need to better understand how such contexts enable disenfranchised learners to adopt an identity as insiders to the world of science, which is the focus of this article.

As other researchers have underlined (Calabrese Barton 2003; Roth 2000), we believe that it is important to 'hear' about the lived experiences of those who grow up differently from the way in which we do. Our goal, therefore, is to understand how disenfranchised youth both view and do science, and how they come to identify themselves as 'someone who can do science'. Our contexts for exploring what 'doing science' means to these youth include two out-of-school learning environments.

Theoretical orientation

In line with qualitative research on learning environments that has underlined the interactive, social and cultural nature of learning (Tal 2001; Tobin and Fraser 1998) and the need to refrain from a separation of the individual and the environment (Roth 2000), we approach our study from a socio-cultural-historical perspective (Vygotsky 1978, 1987). Accordingly, we focus on language use and social interaction among youth as they do science, acknowledging that appropriation through science, dialogue or other practices takes place within the zone of proximal development (ZPD), defined as "the region of activity that learners can navigate with aid from a supporting context, supporting but not limited to people" (Brown et al. 1993, p. 191). We assume that learners, at home, at museum exhibits or in the classroom, "undergo quite profound changes ... by engaging in joint activity and conversations with other people" (Edwards and Mercer 1987, p. 19) in such zones. Human activity is also understood as mediated by cultural tools such as

language and action. Furthermore, learning is constituted by who we are and are becoming in that "what people learn is a function of their transforming roles and understanding in the activities in which they participate" (Rogoff 1994, p. 209). Changes in knowing are taken as associated with changes in social being, a dialectic at the heart of socio-cultural-historical theory and essential to the study of the effectiveness of learning environments. In line with these assumptions, we closely examine how two youth talk and do science as they interact with exhibits in an aquarium and as two others are engaged in project-based science activities in an after-school program. We simultaneously explore how participants' identity and position within science and these settings mediate such meaning-making and perceptions of learning environments as places that matter.

Method

We rely on qualitative case studies of two informal educational contexts, together making up for a multi-sited ethnography (Marcus 1995). The following program features made such a comparison possible: (1) they offered hands-on science activities through a youth-centred approach; (2) the activities and settings were voluntarily sought out; (3) the settings served low-income, ethnically-diverse and linguistically-diverse inner-city youth at the elementary level; and (4) they included participation over time. We describe the two learning contexts next.

Case 1. Families talk science in two languages in a marine discovery centre

The Seymour Marine Discovery Center, a research and education facility in Northern California, was designed to reflect the activity of scientists. Like many other informal places of learning, Center staff are interested in meeting the needs of culturally- and linguistically-diverse families. The aim of the larger study was to explore scientific sense making among 20 Spanish-speaking Mexican-descent Head Start families as they are engaged with four life science exhibits (Ash 2004). Families were recruited through a regional Head Start program and had at least one child of Head Start age (4–6) and one child between the ages of 8 and 11 years. The visits ranged from approximately 20 min to over 80 min and were video recorded. The post-family interviews and the individual student interviews used a stimulated recall technique.

Case 2. After-school program 'Scientifines'

Scientifines is an after-school science program in Canada. Since 1986, the program has been serving girls from two neighbourhood schools within a community that is poor and ethnically diverse and has many first-generation immigrants. Forty girls were present each day—a stable participation structure across the past 4 years. The goal of the program is to get the girls interested in science, but also to offer tools that might help them to be successful in the future. We draw upon a 1-year ethnographic case study (including ethnographic video, fieldnotes and interview data) of 19 girls who completed eight different science fair projects, working on them one afternoon a week (Fall 2003–Spring 2004), as well as follow-up interview data collected at the end of the girls' second or third year of participation (Spring 2005).

Two representative youth were selected in each setting from a larger data set. Through re-reading of observational notes and interview transcripts, as well as reviewing video,

case stories were constructed to illuminate the lived experiences of the target youth, while also exploring the meaning these contexts and experiences held for the four students (Calabrese Barton 2003; Witherell and Noddings 1991). Because youth in the aquarium talked both Spanish and English, often interchangeably, the dialogue is presented in both languages; the data from the after-school program was originally in French but, once they were analysed, they were translated into English to facilitate readability. Despite such language differences, youth in both settings were first-generation immigrants, struggling with similar issues of integration, racism and poverty.

Results

How participation increases access to science in school and life: The aquarium

The aquarium stories underline how participation in out-of-school science-related activities increases access to science both in school and in life. The first case underlines how several meaningful learning opportunities in a marine discovery centre helped Franco to develop an identity as a 'novice' science scholar. Eva's story makes evident the value of such opportunities for marginalised youth interested in science who, as newcomers and immigrants, struggle to make it in the educational system.

Case 1. Franco who valued the opportunity to learn and take on an identity as a scholar

Franco, a 12-year-old bilingual, Mexican-American male, was a typical participant. He was the second child of four, including two boys (Franco and 17-year-old Geraldo) and two girls (5-year-old Leslie and 2-year-old Sera). Coming from Tijuana, Mexico, they had been in the USA for 3 years. Neither of Franco's parent's education went beyond Grade 8. The family's only prior museum experience was a single visit to the Monterey Bay Aquarium as part of the 5-year-old daughter's Head Start program. The mother stated that, in Mexico, the aquatic sciences are simply "learned from books".

In the following exchange, the interviewer probed Franco about what he had learned about the leopard shark during his first visit; he had been asked to take Polaroid pictures of his favourite animals and plants.

Excerpt 1

Franco:	Those are the sharks. [Pointing to a picture he had just taken with a Polaroid camera, as part of the stimulated recall interview] I like their eyes, and their mouth, and how they are really smart.
Interviewer:	You think they are smart. Why?
Franco:	When they were feeding them, when they were letting it [the food] go, so that the rest would eat it, he [the shark] right away would go to take it away from them. And, I said that one, that one does learn how to take it away so that it didn't get left without eating. And also that they don't fight among themselves. And, also the other ones didn't, didn't fight against them.
Interviewer:	And, had you seen sharks like these before? [leopard sharks]

Franco: Not like these, but the big ones, yes.
Interviewer: And, did you know something about sharks before you came here?
Franco: No
Interviewer: No? And did you learn something about them today?
Franco: Yes
Interviewer: Like what?
Franco: Ah, hah, yes, their intelligence and that they're very similar to the big ones. And, and I liked how they had the same things that the big ones have. The fins that they have.
And also that thingie, so it can swim. The part, the one at the back so it can move faster and be more agile. And I also liked how long they are.
Interviewer: Yes, yes? So, so, would you like to learn more about them?
Franco: A lot more. Eh, eh, eh, (things like) if it likes salt water or natural water, and if it doesn't, doesn't it affect them to be in polluted waters? Like, like how there are other (kinds of) polluted water(s) that even the fish (can) die. (in)

Franco knew little about sharks before coming to the Seymour Marine Discovery Center, but now had many questions. His talk also attests to keen observations and positions him as someone interested in learning about science. Despite his interest, he differentiated the kind of science that he did at this marine discovery centre from the science in school. Yet, he wanted to connect the two. When asked about whether he ever talked about the things he had seen in the museum in school, he noted:

Excerpt 2

Franco: No, but on Monday I'm going to tell them that I came here, so that they come and go through it and see that it's nice.
Interviewer: Ah, okay. And, um, do you have science class at school?
Franco: We study energy from, from the sun or from the earth.
Interviewer: Ah, hah. Okay. And, tell me, what do you think science is?
Franco: Let's see, like, finding out what it is, like a scientist. Like other types of things.
Interviewer: Okay. And what do scientists do?
Franco: They investigate that, that which, that which, that which they want to.

Franco listed topics from his science class which he associated with how scientists do science; these topics were different from what he learned about in the Seymour Marine Discovery Center. His eagerness to share with his class, however, suggests that his experience was important to him and seen as relevant to school too. The excerpt below, from Franco's second family visit to the Seymour Marine Discovery Center, is a short exchange between the father, Franco and Antonio (the mediator):

Excerpt 3

Franco: 'Ire, apá. Es él que a mi me gusta. Es él que me gusta a mi más.
[Look, Pa. It's the one that I like. It's the one that I like the most.]

Father: ¿Es pescado?
[Is it a fish?]
Franco: Mm, hm. Un tiburón, así en su forma. No sé. Se me hace que es un tiburón.
[Mm, hm. A shark, like, in its shape. It seems to me that it's a shark.]
Father: Eh. Es ¿Es tiburón, o, o nada más tiene forma de tiburón?
[Yeah. Is it, is it a shark or, or does it just have the shape of a shark?]
Franco: (To Antonio) Es un tiburón, ¿no?
(To Antonio) [It's a shark, no?]
Antonio: Sí es tiburón.
[Yes, it is a shark.]
Father: Es tiburón, ¿'erdad? Es un tiburoncito, pero es, como dicen. ¿Es tiburón gris? ¿No, verdad? ¿Rayado?
[It's a shark, right? It's a little shark, but it's, like they call it, is it a grey shark? No, huh? Striped?]
Franco: Como quien dice, tienen muchos nombres.
[Like one could say, it has a lot of names.]
(later) Leopardo.
(later) [Leopard.]

Franco shared his interest by naming his favourite—the leopard shark—for his father, who was puzzled about its identity. Unconvinced, the father later asked the mother if "it's a shark". Yet, Franco took on the role of expert to share his expertise with his father. Franco also had the social support of the family, an expert from the museum (Antonio), and the actual museum display itself, as he became more engaged in observing and learning about the leopard shark. This level of social support is not always available in learning and teaching settings. The family members accessed information in both Spanish and English, and used each other as resources rather than always relying on the exhibit designers.

During the family's post interview about the second visit, the mediator asked about the family's impressions, their favourite exhibit and animals. Predictably they revisited the shark:

Excerpt 4

Father: Pero estuve viendo bien y dije: "No, este es tiburón."
[But I was looking at it closely and I said: "No, this is a shark." It's just that I don't know what kind of shark it could be.]
Antonio: Franco, ¿Cuál es el te gustó más?
[Franco, which one did you like the most?]
Franco: El tiburón.
[The shark.]
Antonio: ¿Por qué?
[Why?]
Franco: Porque me, me llamó la atención como tiene los dientes bien chiquitos. Como tiene la parte de abajo blanca, a, a, a lo diferente de lo de arriba. Y no sé si sean dientes que tiene, o bigote lo que tiene aquí al lado.
[Because, how it has its teeth so tiny caught my attention. How it has the underneath part white, eh, eh, different from what it is on top. And, I don't know if they're teeth, or whiskers, what it has here on the side.]

Franco was central to the family social dialogue about the shark. The father questioned his son about the identification of the shark (as he had not been to the first visit) and Franco had to re-assert his claim to knowledge in the face of his father's repeated questions (Excerpt 3). These exchanges offered Franco the opportunity to talk science and to position himself as knowledgeable, even if such talk had little in common with his school science practice. We saw in Franco a youth poised to learn more about science. The Seymour Marine Discovery Center appears as an ideal setting, replete with potential social supports to foster his development.

Case 2. Eva, budding marine scientist, doctor, astronomer, scientist

Eva's family included mother, father, daughter Eva (aged 10 years), son Antonio (aged 8 years) and the Head Start son, Ricardo (aged 5 years). Eva and her family participated in yearly visits and interviews at the Monterey Bay Aquarium from 2001 to 2004. The family had lived in the Monterey area for nine years. Only Eva, the oldest daughter, and the parents were born in Mexico. Neither parents' education went beyond the Grade 6 level. Eva's parents were interested in opportunities that furthered their children's educational experiences. They commented on the lack of such opportunities to visit aquariums/museums in Mexico, due to money and transportation problems.

In line with their philosophy, the parents visited the aquarium more "for the sake of the children than for ourselves". According to the father, it is "hard going to the aquarium, particularly when working 6 days a week". The mother believed that "one cannot stay home, one has to take children to see things", such as camping and the ocean. In the first visit, Eva said that she wanted to work with whales and dolphins. Eva and the mother talked about a large grey whale skeleton on the ceiling and a whale video. Eva taught her mother about whale flippers and shape and how whales communicate. Eva's mother was excited about her daughter's knowledge. During the second visit, Eva said that she wanted to be a doctor, go to Stanford University and be a paediatrician when she grew up. In this visit's stimulated recall interview, Eva explained to the family and the mediator how coral lives. She had learned this on the first visit and had retained it for half a year. She also made a joke using the term 'mermaid's purse', the phrase describing shark eggs. In both visits, Eva had taken on the role of the expert in her family who was impressed by her knowledge.

Eva also recognised that her parents did not have the opportunities that they had provided for her and her siblings. This is apparent in her response to the interviewer's question: "What's made you have the desire to want to go to Stanford and do all those great things? Is it coming more from you, is it coming from your school, is it coming from your parents?" Eva said:

> A little bit of everything. Especially, it was like, my parents, yeah, 'cause they didn't have an opportunity and 'cause they suffered a lot to like provide me with the stuff I needed, like for my better future. Um, I'm not gonna waste their efforts. Because, my life compared to theirs, is like, what I'm doing right now. I might think like hard school and stuff but, compared to their life, it's really a piece of cake. It's like really easy, so, yeah. They just told me to try hard, and like, up to like fifth grade they, they couldn't help me like in my math no more because they didn't really get a lot of education.

Eva was determined to work hard given the many opportunities that were offered to her. Eva also discussed her ongoing interest in marine mammals, an interest which she developed because of her field trips to an aquarium:

Excerpt 5

Eva: Well, at the school I used to go to, every single year, they took you to aquariums. So, every time I went they, this aquarium actually, every single year they took you. But then I moved in third grade and the school I went to really didn't like, take us out, to do stuff. They didn't take us to the aquarium no more, but, they did take us other places, so that was cool. I went to redwoods, and all that stuff.

Interviewer: Is there anything that you've learned for the first time here in the aquarium,

Eva: Yes, a lot of things. The environments, like around the fish. I thought it was just like water and stuff, but no, it's actually more than that. It's the plants, the, the little animals, it's like the food chain.

Interviewer: So, why do you think the other stuff is there? You know, like the plants and coral and everything else?

Eva: When I saw the plants I was like, wow, it's more than just water and fish. I was like, maybe there is a whole 'other world' out there.

School trips to museums supported Eva's developing sense as someone literate in science. Unlike Franco, her in-school and out-of-school experiences seemed aligned. Visiting the aquarium with her class and her family offered her important insights into the marine sciences and the complex science behind such things as the water in the aquarium (ecosystem of water, etc.). Eva also saw connections between science and other subjects taught in school:

Excerpt 6

Eva: Well, we've dissected a squid at school. We learned a lot about underwater. But, in my mind, before we dissected the squid at the end of the year, they were preparing us so much for it. They showed us movies about squids, and their cycle, how they're born, and then they lay eggs, and then they die. How the female lays the eggs. Yeah, so yeah, when we do things like that I can find a connection sometimes.

Interviewer: And how, eh, does your teacher bring in any type of math? Does the biology teacher use any type of math with you guys?

Eva: Yeah. Yeah. Like equations, like, right now we're doing the, what's it called? Oh, photosynthesis? Photosynthesis. And we have to know the equation, like...

Interviewer: That's very complicated!

Eva: ...six CO_2 plus six H_2O, with light makes a sugar molecule with oxygen. Dio, yeah, dioxide.

As her story of the squid dissection suggests, Eva was quite articulate about school science. She had numerous opportunities in the past to relate to science in meaningful ways. The

case differs significantly from Franco, who lacked the confidence to talk much about school science and who had fewer opportunities to do hands-on science and to go on field trips.

Eva talked often about careers in science. In 2001, she wanted to study marine animals, in 2002, she wanted to be a doctor, in 2003, Eva wanted to become an astronaut after a planetarium visit and, in 2004, she talked about becoming a paediatrician. Her comments reflect a deep belief that she 'can do anything' if she just works hard enough. She did not believe in barriers in gaining access to the world of science:

Excerpt 7

Eva:	In fifth grade, I also went to a planetarium and that's when I really got interested in like space and stuff, and, for a while I thought of being an astronaut, and then all I want to do is go to the moon. I'm like 'nah'. Now I want to be a paediatrician. Like the cartoon, I can be anything I want. I can be a football player, I can be a space man, I can be a king. And then he's all, you can be a football-playing king in space!
Interviewer:	You really believe that, don't you Eva. You can do whatever you want?
Eva:	Where there's a will, there's a way!

No matter the year or context, Eva saw herself as someone who can 'do science' and who 'can be anything'. Eva also underlined repeatedly the value of 'doing' science and not simply talking about it. She was an insider to such participatory science whether in the aquarium or the school.

Youth-centred science driven by inquiry is a possibility: The after-school science program

While youth value participatory science, the science also needs to be relevant to their lives, youth centred and driven by inquiry. This became particularly apparent through analysis of youth-initiated science fair projects in our second case study. In fact, the questions that the girls posed and explored, as well as the manner in which the projects evolved over time, both related to the way in which these youth positioned themselves in relation to science. Samira, like Eva, valued any opportunity that helped them become an educated person and to be successful in the future, while Nisha simply wanted to do an experiment and have 'fun' with science.

Case 3. Samira who valued engagement in inquiry science that is relevant to her life

Samira participated in Scientifines for three consecutive years. When we first interviewed her, she was 10 years old and in Grade 5. She came from a large family (at least six siblings) and lived with her parents who had emigrated from Morocco. Although Samira was born in Canada, she spoke Arabic at home and frequently spent her summers in Morocco. Samira's parents encouraged her to participate in the after-school program. As Samira noted, her parents "see it as a ticket towards future success in life". Samira, who wants to become a mathematics teacher one day, came to the program for the 'doing' of science: "I love the experiments we do, like when we made 'glob', which is like a sort of

paste that one can stretch and play with; we put colouring in it too." She also claimed to learn a lot of new things through Scientifines (e.g., "I didn't know that for spaceships it takes oxygen and nitrogen, things like that"). For her, science is "fun when doing experiments, while it also teaches us plenty of new things that we do not yet know because, in school in third year, we do not learn things about science". When asked the following year about what made the program important to her, she noted: "I love science and biology and all that, and at the same time it makes me learn things useful for high school and for my profession later on." The program started to have instrumental value to her and her future. That the program was only for girls did not seem important to her when we talked in the first year. Yet, in her last year, Samira noted its value: "Because I am Muslim and am not really allowed to be in contact with boys; in my religion, it is like that." Later she elaborated: "I love the program because I work only with girls, it makes me feel at ease, I am not really allowed to talk with boys, and so I prefer to be just around girls. It's like a club just for girls."

What made the program stand out the most, however, were the kind of science fair projects in which she engaged over time:

> In the first year, I think I did a project on optical illusions and I remember that there are people who take drugs that are called 'hallucinogenic' and they had illusions. The second year, I did a project on rockets and learned that, when the rocket takes off into space, there are two parts of the rocket that fall in the water and that are then picked up. And this year, I found out that, thanks to fibre optics, the voice can be transferred from one 'phone to another.

Samira said that the science fair projects made her pose questions about everyday things about which she had been curious, such as "something at home, like the telephone, things like that". She seemed to suggest that such kinds of questions are not necessarily the ones that she would explore in school. She liked asking questions about "what oxygen and hydrogen consist of, and other things like that". After completion of her third science fair project, Samira was also able to explain all the steps that the project entailed:

Excerpt 8

Samira:	I did a project about the 'phone. We spoke about the way it works and who invented the 'phone, and then we also shared our hypothesis and explained what we did from beginning to end.
Researcher:	And what was your hypothesis?
Samira:	We asked ourselves one question about how the voice transfers from one 'phone to the other. We thought it has something to do with the echo in the mountains. So for example, I am here and another person is on the other side of the mountain and, if I scream, the other person can hear me. We thought it works something like that.
Researcher:	And then, what did you find out?
Samira:	We found out that it works thanks to fibre optics. That's what's in the 'phone wires.
Researcher:	What interests you the most in that topic?
Samira:	I found out how, every time I talk into the 'phone, my voice makes it into the 'phone of my friend.

Samira struggled to explain how fibre optics is involved in the transmission of sounds, noting that it was a challenging project and that "we had to redo it many times". Yet, Samira felt that her group worked hard to make the project work: "My group, we worked and did not play around, we worked hard, we looked for information on the web, we looked for information at home, in books, in the library. We are like more advanced since we really focused on that project. Once we finished our homework we just kept working on it and, because we all live close to each other, we saw each other all the time." Samira also liked speaking to the public and presenting projects.

Case 4. Nisha who valued the opportunity to 'do' science

Nisha, a newcomer to Scientifines, was 9 years old and in Grade 4 when we began the study. She came to the program because her friends wanted her to come and her father is often at work; thus, she had a place to do her homework. Nisha liked "doing the experiments". She did an experiment with her team exploring "what happens when one mixes an acid with a base", and wondering whether this "always creates a reaction". As she explained: "With our experiment, we wanted to see if one can mix any kind of base with fruit acids—and, if that does not work, we can show how it does work with vinegar and baking soda." After some conceptual work, her team started mixing different things:

Excerpt 9

Adult:	What are you doing?
Mieka:	We mixed this, this, this and this. [points to what they had mixed]
Adult:	What is this?
All girls:	Vinegar!
Adult:	What does vinegar do? What is it?
Nisha:	Vinegar, it is like something that makes something go up. [talks as she continues with experiment]
Mona:	NO! vinegar, it's an acid, a liquid acid, that's all. [confirms further what Nisha said]
Adult:	OK, but why do you add vinegar?
Nisha:	Because, I think that the vapour will make it go up.
Mieka:	Because it is like the vapour will make it go up a bit.
Adult:	What if you do not put it, what if you just put the acidity of a fruit?
Mona:	We will do like different acid fruits, so we will put lemon in it, and then we will observe what happens. If it works we will use less in it.
Adult:	Ah, ok.

Nisha, like her peers, was heavily involved in mixing things. Yet, we see in the exchange with the adult, Nisha did not quite understand how the acidity of fruits could have replaced vinegar. She was doing science without necessarily understanding it. Yet, it is this kind of doing that she valued the most: "Doing the experiment, I like that a lot. One can take lemon, lime, grapefruit, and then we discovered that it also works with cranberry, with baking powder; we had a reaction. That's what I like most!" Such involvement positioned her as capable of doing science.

Nisha also saw that learning science was important and would serve her well in high school. When asked what she learned from her project, Nisha noted: "At first, I did not understand citric acid but now I start to understand how it works. I understand all." For Nisha, the most important thing was to "be with my friends"; the science part was secondary. Nisha decided not to participate in the program the following year, saying that "I wanted to do something else for a change". However, she did come back to the program the year after for the final presentation of projects, being somewhat regretful of her decision and remembering the fun of "doing experiments".

Discussion

We began this article by questioning whether such learning environments as the aquarium or the after-school program enable disenfranchised learners to take on an identity as insiders to the world of science. Our four stories support a positive answer. These opportunities clearly mattered to the youth and helped to shape them in important ways. We saw the most powerful evidence in Eva's and Mira's long-term experiences. Franco's and Nisha's stories also attest to short-term gains in that Nisha stayed in touch with the program while, for Franco, becoming an insider to science suddenly became a possibility. Eva's and Samira's participation contributed to their perceived possible future selves as an educated person and, for Eva, also as an insider to science. Taken together, our study underlines the importance of simultaneously exploring forms of participation and identity and to refrain from a separation of 'coming to know' and 'the knower'.

Hull and Greeno (2006) suggest that the concepts of *identity* and *agency* are central to understanding learning in any context. One can talk of *positional identity*, which refers to ways in which individuals are entitled, expected and obligated to participate; seen by themselves but also by the system within which they are caught up (Holland et al. 1998). In the four stories, the youth were positioned as capable of taking advantage of the educational opportunities offered to them. However, many ethnically and linguistically diverse youth from low-income backgrounds are positioned as 'problems' by the system (Heath and McLaughlin 1996), which then results in the positioning of self as outsiders, as was the case for Franco who knew too well that science is reserved for the elite. Yet, through participation in science at the margins, these four students 'had a taste' and an opportunity to experience insider status. As Holland et al. (1998)'s work underlines, one can also talk of *voice*, referring to "ways in which individuals present and represent themselves to others and to themselves, thereby authoring and co-authoring their identities in the social world in which they participate" (Hull and Greeno 2006, p. 78). When looking at Eva and Samira, both believed that they could become educated and positioned themselves in that manner. For them, it was simply a matter of working hard and making the best out of opportunities offered through sites such as the aquarium or the after-school program. In contrast, Eva and Nisha presented themselves as participants in science at the margins and in line with their perceived role in the system.

Clearly, the two ways of examining identity projects and learning are valuable. Through our examination of talk by youth about their past and 'who they have been', as well as about the future and who they 'want to become', we have offered glimpses of identity constructions in the moment (Hull and Greeno 2006, p. 84). We also showed how all four youth had an opportunity to participate in a discourse to which they had had little access in the past and how such participation made them take on certain roles and pursue certain goals and activities and, in turn, how this made them become different kinds of

people—youth who *can* do science. Our stories show that "...an identity that is favorable to science is not constructed in science class, it has to be nurtured by us and by others, in more parts of the day than a single classroom hour, outside school as well as inside, after school and after schooling" (Lemke 2002, p. 41).

As researchers of learning environments, we have to be much more serious about understanding learners' literacy trajectories and identity formations across settings and, hence, across space but also time. In doing so, learning environment research is also situated in its practice (Roth 2000)—in our case, the 'lifeworlds' of ethnically and linguistically diverse youth from low-income backgrounds. Through our four case studies, we have attempted to show what listening in on youth might look like and how this can result in rich descriptions that offer us valuable insights into a world about which we as researchers might know so little. These descriptions then might help us to advance our mission of developing learning environments that matter to and are accessible to all youth, irrespective of who they are.

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