Science in the Making at the Margin

A Multisited Ethnography of Learning and Becoming in an Afterschool Program, a Garden, and a Math and Science Upward Bound Program

Jrène Rahm

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SCIENCE IN THE MAKING AT THE MARGIN

NEW DIRECTIONS IN MATHEMATICS AND SCIENCE EDUCATION
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Scope

Mathematics and science education are in a state of change. Received models of teaching, curriculum, and researching in the two fields are adopting and developing new ways of thinking about how people of all ages know, learn, and develop. The recent literature in both fields includes contributions focusing on issues and using theoretical frames that were unthinkable a decade ago. For example, we see an increase in the use of conceptual and methodological tools from anthropology and semiotics to understand how different forms of knowledge are interconnected, how students learn, how textbooks are written, etcetera. Science and mathematics educators also have turned to issues such as identity and emotion as salient to the way in which people of all ages display and develop knowledge and skills. And they use dialectical or phenomenological approaches to answer ever arising questions about learning and development in science and mathematics.

The purpose of this series is to encourage the publication of books that are close to the cutting edge of both fields. The series aims at becoming a leader in providing refreshing and bold new work—rather than out-of-date reproductions of past states of the art—shaping both fields more than reproducing them, thereby closing the traditional gap that exists between journal articles and books in terms of their salience about what is new. The series is intended not only to foster books concerned with knowing, learning, and teaching in school but also with doing and learning mathematics and science across the whole lifespan (e.g., science in kindergarten; mathematics at work); and it is to be a vehicle for publishing books that fall between the two domains—such as when scientists learn about graphs and graphing as part of their work.

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PART 5: CONCLUSION

PREFACE

In this book, I take you on a journey into programs about science and the lives of diverse youth who I got to know over years of engaging in research on informal science learning. I finalize my writing about learning and becoming within informal learning environments at a time when such research has gained much attention, as evidenced by the new document, "Learning science in informal environments", commissioned by the National Research Council and published in 2009. The report offers a timely synthesis of a field that has a much longer history than most newcomers are aware of. In part, given its lack of a home, research on informal learning is dispersed and at times hard to locate. Some demarcations, however, were maybe at cause too. Many schools of education were preoccupied with the study of learning and teaching in schools only. Today, given a strong move towards transdisciplinarity and the recognition that learning and becoming is only in part spatially marked, such boundaries are slowly disappearing. The youth I studied taught me much about how learning and becoming is interspatially marked and stretched across space. We talked a lot about school in the garden and I embarked often with them on imaginary journeys into their schools. Simultaneously, the programs I studied and engaged in at their elbows offered them with unique complementary learning opportunities that were crucial in shaping their ways of knowing and becoming.

Grounded in sociocultural-historical theory, the analysis I present in this book offers some insights into some of the complexities and contradictions among spaces of learning that define the lives of youth today. I hope this book helps convince educators that genuine learning happens in school as well as out, and that the two are complementary and constitutive of youths' literacy development and of who they are and are becoming. The two are constitutive of youths' lives and best understood as a complex dynamic rather than as a dichotomy. Learning and becoming across space and over time define youths' literacy and identity work and need to be better understood in conjunction. The book offers a story about such learning and becoming in and of science. It builds upon theories of youth development and youth empowerment, as well as the literacy studies. The book takes us on a journey into a world of science that is vast yet unfortunately also often marginalized in that such science learning often does not carry the power of school science knowledge.

The book offers the reader with a partial view of the world of diverse youth and their engagement in and with science, youth marked by histories that constitute who they are and can become in the future, histories little talked about in the literature on informal science learning. It is only a beginning however. We have yet to appreciate what it means to grow up in an era of globalization — of movement, diversity, complexity, diaspora, and hybridity at all levels of the system — and how that influences engagement in and with science across space and time. I begin that conversation together with youth, yet still more stories are needed.

PREFACE

Writing this book was a big and long adventure made possible through many generous contributions in terms of feedback, time and support. I begin with COSMOS, the program I studied in Colorado, USA, and like to thank the many individuals that made that program happen and that welcomed me among them. I thank in particular John Moore, program director at the time of the study and a professional colleague who taught me much about university outreach, ecology, scholarship, and who never tired of helping out. I thank Ann Ratcliffe and Rene Oya of COSMOS who ran the program in different ways at the time of the study for all their support as I struggled in my position as a 'new' professor at the University of Northern Colorado. Also many thanks to Wendy Naughton, Jayne Downey, Lisa Marie Miramontes, and Michael Opferman, graduate students who helped with data collection and analysis in Colorado. I am grateful for internal grants to the University of Northern Colorado, which made data collection possible. Returning to Canada, I thank Marcela Cid and Violène Simard, the directors of Les Scientifines and Jardins-jeunes and their teams, who were open to the idea that I would hang out with them over time and who were and still are supportive in so many ways. I am thankful to Marie-Paule Martel-Reny and Itzel Vazquez for their continuous encouragement, support and help with data collection, analysis and editing. They also smoothed out struggles I experienced as a newcomer to Quebec and its political issues around language and immigrants like me. They played a key role in helping me translate some of the French data in ways respectful of youths' ways with words. Special thanks to Allison Gonsalves and Stephen Peters who both offered much needed editing help at different moments and great insights into the meaning making of science — thank you for being such critical readers of the manuscript and teaching me so much more about English. As the editor of this book series, Michael Wolff-Roth helped with the minute details of the typesetting of the manuscript and offered much encouragement to complete the project. Data collection and analysis in Montreal was made possible through financial support from the Social Sciences and Humanities Research Council of Canada and Fonds de recherche sur la société et la culture, Québec. Many other professional colleagues contributed in different ways over time to my trajectory as a researcher. I am particularly thankful to Doris Ash, Leslie Edwards, Karen Tonso, Jennifer Vadeboncoeur for conversations about themes touched upon in this book. I also thank Steven Guberman for exposing me to Vygotsky and sociocultural-historical theory, and Margaret Eisenhart to ethnography — a combination of perspectives that served me well. I thank Paul Charbonneau for proof reading and support, and Nicolas and Roland for their smiles and help with the cover page. In closing, I thank all the youth that participated and without whom this project would not have been possible. I hope to have done justice to what you tried to share with me and hope it will help to make genuine learning possible for many other youth in the future. Thank you for letting me learn from you!

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INTRODUCTION

The study of science in the making in settings other than school is becoming very popular. Initially, the study of informal learning was the territory of developmental psychologists who never questioned the assumption that learning happens beyond school walls and possibly wherever children spend time (Villarruel & Lerner, 1994; Goodnow, Miller & Kessel, 1995). Most of those studies, however, were limited to children not yet of school age, documenting what they were doing elsewhere, in their family, in daycare, or on the street. Few studies focused on learning and development outside of school or in conjunction with schooling. At the same time, some fascinating work surfaced on the cognitive aspects of informal learning by a number of authors inspired by sociocultural-historical theory, cross-cultural research, and anthropology (Cole, 1996; Rogoff & Lave, 1984). That work started to open up the field of learning to an understanding and appreciation of its many forms and its constituted nature by context. It also led to a dichotomy between formal and informal learning that has been rather unproductive for the field, however (Resnick, 1987). Too often, all the good was relegated to out-of-school contexts and that which is repressive to schools.

When exploring the field of informal science learning in North America, one is struck by its long history and the many kinds of institutions it involves. Their educational role was often conceptualized in opposition to schooling. They could offer low-risk experiences and self-motivated participation while also compensating, at least in part, for lack of meaningful hands-on science activities in school (Crane, Nicholson, Bitgood, & Chen, 1994; Katz & McGinnis, 1999). Much research on informal science learning at the time was closely associated with particular institutions, such as science museums, science centers, aquariums, parks, television and radio, and later renamed as free-choice science learning to underline that such learning was driven by a person's needs and interests and entailed some level of choice and control over learning (Falk, Donovan, & Woods, 2001). Research on informal science learning environments such as university outreach programs and afterschool and community programs driven by a youth development perspective with a focus on science, was later in coming (Delgado, 2002).

Today, the study of science in the making outside of school has become political, at least for those seriously concerned with declining scientific literacy levels among youth and youths' recurrent lack of interest in pursuing a career in science. It is as if informal science and the out-of-school learning field has been "discovered" as a potential quick fix to an ever increasing problem of science illiteracy in North America. After many years of trying to change school science practices for the better with few results, it may not be surprising that afterschool and community programs are now solicited and charged to play a more important role. Yet what role they should or can play is far from clear. Unfortunately, in our age of accountability, and given our fear of the consequences of an ever

diminishing science work force, the tendency to simply extend the school day and offer more of the same is frighteningly strong. Recent position papers, commissioned by the Coalition of Science After School (CSAS) speak on that issue and critically examine the potential of after-school programs to serve as an infrastructure to foster youths' interest and engagement in science, technology, engineering, and math content (STEM) early on in life. They underline well that a quick fix attitude will not work. For example, Dierking (2007) concludes with concerns about equal access to quality school and out-of-school learning opportunities and emphasizes the fact that historically under-served populations have been excluded for a long time from most "educationally-oriented free-choice learning institutions, including museums, public television, radio, specialty magazines and even to a degree newspapers and books" — institutions that "have variously been accused of being elitist" (p. 11). Yohalem and Shouse (2007) argue that the delivery of high quality, effective after-school programs with a STEM focus, although interesting, would need much investment in "capacity building" (p. 1). Delgado (2002) reminds us of the need to focus on positive youth development when adding science to such afterschool and community programs. Then, youth are respected and offered, often for the first time, the opportunity to experience a positive and agentive sense of self while also being positioned as able science learners (Hull, 2008).

Clearly, afterschool and community programs alone would fail to compensate for all the lost ground in youths' science literacy development and such should also not be their task. We know, however, that they play an important complementary role to other institutions supportive of science literacy development. This is not surprising if we take seriously the theoretical notions behind learning that are at the heart of this book. I assume that learning and science literacy development entails an understanding of the range, or repertoires of cultural practices youth participate in, such as afterschool science programs, science leisure activities, museums, summer science camps, science activities in community youth programs, in their families, and in school, to name a few (Gutiérrez & Rogoff, 2003). We know that participation in such settings makes a difference in terms of youths' academic standing and leads to increases in their levels of science literacy, interest, positive attitudes and confidence in science, as well as higher chances of pursuing career trajectories within the sciences (Atwater, Colson, & Simpson, 1999; Fadigan & Hammrich, 2004). Similarly, university-based outreach science programs show positive outcomes in terms of students' understanding of the nature of science and scientific inquiry, while also opening up participants' eyes to science career possibilities (Bell, Blair, Crawford, & Lederman, 2003; Bouillion and Gomez 2001). Afterschool science programs for girls have been found to be effective for improving self-confidence and interest in science, while also positively impacting girls' sometimes limited view of women's roles within science (Campbell and Steinbrueck 1996; Ferreira 2002). Yet, as emphasized by McClure and Rodriguez (2007) in their report on out-of-school time programs (OST), we need to know more about *why, how, and for whom* such programs make a difference. We know little about meaning making of science — how children and youth create their own

understandings of science — in such sites and the kinds of identity work such places support and make possible at the time of participation, but also over time as the youth move on and continue on their trajectories towards adulthood. Does engagement in science in such places offer youth access to science and science-related communities or possibly even careers related to or in science? How is sustained engagement in informal science education activities experienced and understood by the participants? And what contributions does it make over time in terms of science literacy development and identity work?

This book will offer answers to such questions through an in depth and theoretically well-grounded multisited ethnography of three very different OST programs: an afterschool program for girls only, a garden, and a Math and Science Upward Bound Program. Essentially, the book is about learning outside of school, learning being about the making of meaning and the making of identity inspired by sociocultural-historical theory and extensions thereof. It is assumed that through participation in science practices at the margin, youth co-construct new levels of understanding of science, of what science means and also come to position themselves in relation to science in new ways. In line with activity theory and sociocultural-historical theory (or CHAT; Cole, 1996; Engeström, 1987; Engeström, Miettinen, & Punamäki, 1999; Vygotsky, 1987), I take the artifact-mediated action as the primary unit of analysis. I study the activity and the tools the youth invoke as they engage in science in the different sites to make meaning of science and of themselves in relation to that activity. Yet, a focus on activity (e.g., participation in an afterschool science program), also prompts the study of intentionality and purpose behind actions in that activity. Forms of engagement are understood as being tied to the youths' motives for participation (e.g., to be with friends, to learn more science, etc.). Accordingly, I explore how motives for participation mediate forms of participation over time. Furthermore, changes in ways of knowing are also constituted by youths' identity work and in particular, the manner they position themselves in relation to science and the science practice they participate in, as well as in relation to education and the becoming of an educated person. The manner these factors play out is explored in the context of longitudinal case studies of a selection of the youth from the three research sites. In sum, the book addresses questions such as the following:

– What forms of participation do the practices I explore here offer for the doing of science?
– How is meaning made of science in these settings?
– How are such forms and meaning making experienced in relation to others in school, at home, or other leisure activities?
– What motives drive youths' participation and how do they constitute forms of participation and meaning making over time?
– How do such forms of participation and meaning making constitute youths' identity work and positioning in science and beyond at the time of participation, but also across time and space as they move along on their life-learning trajectories?

What makes this book unique is its application of a multisited ethnography, a methodology particularly promising in capturing learning within different sites (Marcus, 1998). Mobile ethnographies are certainly challenging. Yet, the book shows in what ways they are potentially interesting tools to understand learning and becoming across time and space when such learning and identity work is understood as fluid, dynamic and ever-changing. The book is an important addition to others that have examined meaning making and identity work from a sociocultural-historical perspective in science classrooms (Roth & Tobin, 2007; Roth, 2006), and researchers who have started to focus on engagement in science guided by a vision of science as an embodied practice (Calabrese Barton, 2003; Calabrese Barton & Brickhouse, 2006). Given its methodology, it moves the conversation on informal science learning forward in that it explores three different yet comparative science practices simultaneously and thereby offers a rich story of what may count as learning in informal contexts, a question still in need of an answer. I like to rephrase the latter question somewhat, however, in that my goal is to primarily describe and analyze youths' engagement with science in the three sites studied. I attempt to do so in terms of the ways the youth talked about these practices and themselves as well as in terms of the observed forms of participation that the sites supported and that could be observed through the video ethnographies that were conducted. Thereby, I try to present the youths' perspective on informal science as they experienced it, discussed it with me, and allowed me to observe. I spent considerable time in each site as a participant observer, gaining the youths' confidence as I tried to capture their ways of talking and engaging in science at their elbows by video and in my fieldnotes. Only upon securing youths' confidence could I explore what they had to say about their positioning in science and beyond. What I present in the book is a "bricolage" of many diverse data sources that I gathered over much time in the three sites.

WHY TALK ABOUT SCIENCE IN THE MAKING AT THE MARGIN

In this book, I talk about diverse urban youths' engagement in informal science activities. It is a population that has been studied little in informal science settings and that has for a long time struggled with accessibility issues to quality science museum activities and science afterschool and community programs for a variety of reasons. Informal science activities that target diverse youth are too often about bringing diversity into the STEM pipeline and/or prevention — to keep youth out of trouble. They are not necessarily concerned per se about equity in terms of accessibility. It is often about offering outsiders the means to become insiders to elite science or to get a taste of it and for it. Yet, the youths' daily lives, the assets they bring to such science making practices, and the possibility of a co-opted science that would be respectful of who they are and are becoming never enters the conversation. A parallel can be drawn between the youth in this book and the women discussed by Eisenhart and Finkel (1998), who engage in science in subordinate positions. The youth portrayed in this book engaged in "subordinate"

science activities, or science practices at the margin. That is, the programs and settings I describe were a means to engage in elite science in COSMOS and to some degree in Les Scientifines, or a means to engage in meaningful science in the garden. Yet, such forms of engagement in science did not necessarily translate into recognized capital by the system and, as such, could not officially compensate for inadequate school science. Engagement in these science practices did not necessarily make elite science more accessible for the participating youth. Most were and remained positioned as outsiders to the world of science. Despite such a marginalization, I document the diverse forms of engagement in informal science and the complex manner they constitute youths' positioning in science and beyond. An understanding and appreciation of the vast diversity of trajectories within and beyond science may help us clarify why so many diverse youth in particular, are, as is, "underserved, underrepresented, and disenfranchised in science" (Lee & Luykx, 2006, p. 160). It may explain why engagement in science is experienced by many diverse urban youth as empowering in such marginal settings yet translates into little or no agency over time beyond those sites, making them participants in science at the margin at best.

A WORD ABOUT SCIENCE LITERACY

Math and Science Upward Bound Programs were developed to address the under-representation of diverse youth in the science pipeline. Yet, the message of the book is not intended to make the case that informal science settings are key to bringing outsiders in. Instead, my intention is to study such settings and practices in their own right and to offer rich descriptions of meaning making of science and positioning in science in such places. Evidently, I conceptualize science literacy and engagement in science in broad ways. To engage in science fairs, to garden, or to work at the elbows of scientists essentially entail different forms of engagement in and with science. Furthermore, I assume that science literacy emerges from engagement in such diverse science practices over time. Yet, as I alluded to earlier, such engagement is never neutral. Instead, some forms of engagement in science carry more power than others within our current educational system. Take for instance engagement in science at the elbows of scientists, a form of apprenticeship that has been considered by some as an authentic means to become an insider to science. In contrast, other researchers advocate for a science that is place-based, co-opted by youth and tied to who they are and are becoming, a science that emerges from engagement within meaningful and contextually rich activities in which youth have the opportunity to take on real roles and become agents of science (Rahm, Miller, Hartley, & Moore, 2003). This book builds on the latter view and approaches science literacy as broadly and culturally defined, as entailing many diverse forms of practices and means to engage in and with science constitutive of the actors and their worlds, and hence, appropriated, co-opted and owned to some degree by the youth who do it.

OVERVIEW OF THE ORGANIZATION OF THE BOOK

There are four parts to the book. In the first part, I offer the kind of background that will enhance the reading of the data chapters in parts two to four. In chapter 1, I begin with a brief history on informal science education, to be followed by a synthesis of some of the literature in terms of the sites studied, beginning with what is known about afterschool programs in science for girls only, gardening programs in botanical gardens, and ending with a discussion of Math and Science Upward Bound programs. In chapter 2, I lay out the theoretical framework, the sociocultural-historical approach to the study of meaning making of science and identity work that is at the heart of the book. In chapter 3, I complete the section with an overview of the methodological approach taken, making the case for a multisited ethnography that allows one to highlight the particulars of a site while also supporting some level of generalization across sites.

In part 2 of the book, I examine what science in the making entailed in each site. The section begins with a brief introduction to justify the initial presentation of each case as separate, an organization that makes possible to bring to the foreground the particulars of each site. In chapter 4, I describe the science in the making in Les Scientifines, in chapter 5, I look at the making of science in the garden program Jardins-jeunes, and in chapter 6, I explore science in the making in the Math and Science Upward Bound Program COSMOS. In chapter 7, I offer stories from each program about particulars that went beyond science and that made the programs special in the eyes of youth. As I will show, they are crucial for understanding the significance of the science practices in the lives of the diverse youth studied. A synthesis follows, underlining the diversity of characteristics that made up the science practices at the margin. As will be discussed, such diversity does not exclude the identification of some general features that define forms of science literacy development beyond school and that may make such practices that interesting to youth.

In part 3, I explore youths' motives for participation. I separate such a discussion in terms of the three settings studied, beginning with Les Scientifines in chapter 8, followed by Jardins-jeunes in chapter 9, and COSMOS in chapter 10. I conclude part 3 with a synthesis in which I explore in what ways motives for participation were related to youths' perception of self within the educational system while I also examine the relationship among the motives for participation, the youths' notions of science, and the role youth could play in each setting.

In part 4, I focus on the ways engagement in science over time and across space (or practices) played out in youths' science literacy development and positioning work in and beyond science. In chapter 11, I begin with an exploration of time and show in what ways engagement in a fire ecology project over the course of the three program years of COSMOS contributed to the development of different facets of science literacy among participating youth. In chapter 12, I explore the spatial dimension of science learning and identity work as I follow three girls' forms of participation and positioning work in Les Scientifines and subsequently, Jardins-jeunes. In chapter 13, the time and spatial dimensions are examined

together as I describe the role of the programs Les Scientifines and Jardins-jeunes in the lives of two youth that I followed for three years. I describe in what ways the cultural capital at home mediated the youths' trajectories, in the first case for a first-generation immigrant, and in the second case, for a youth who discovered science through participation in the program yet then opted out of science later on. Chapter 14 further expands upon the former themes and explores four COSMOS youths' navigations and learning trajectories over time and across space, by documenting their positioning work in science in COSMOS and then subsequently in college, based on follow-up interviews four years later. It allows for an examination of whether the youth became what the programs were preparing them for and whether they appropriated the intentional identities the program set out for them, such as entering college, and possibly the science pipeline by pursuing a University degree in science. I conclude that section with a synthesis. Following part 4, I offer a conclusion and explore three issues that the studies brought to the foreground: (a) the multiplicity of informal science learning, (b) issues of accessibility to such diverse ways of engaging in science and becoming in and beyond science, and (c) the methodological challenges its study poses. I conclude with a word about the significance of informal science learning and positioning in science and beyond over time and across space.

PART 1

LEARNING SCIENCE OUTSIDE OF SCHOOL

SCIENCE IN THE MAKING OUTSIDE OF SCHOOL: A SYNTHESIS OF POSSIBILITIES AND CHALLENGES

A good education requires education about diversity in a diverse environment. (Bowen & Bok, 1998, in Banks et al., 2007, p. 8)

Youth today come into contact with science in many different settings and contexts. They have to manage to navigate among such spaces, to work within them, and to define continuously their relationship to these multiple science practices both at the local and global levels. Such multiple forms of participation and navigations among diverse learning sites are also at the heart of science literacy development and the becoming of an educated person (Lam, 2006). And for this reason, the study of learning and science literacy development entails an understanding of the range, or repertoires of cultural practices youth participate in, such as afterschool science programs, science leisure activities, museums, summer science camps, science activities in community youth programs, in their families, and in school, to name a few (Gutiérrez & Rogoff, 2003). In line with such an argument, some studies started to explore the ways in which home environment factors constitute science literacy development, science achievement and attitude. For instance, Schibeci and Riley (1986) examined the influence of race, gender, home environment, amount of homework, and parental education on students' achievement and attitude in science, showing that such factors play an important role. Other studies underline how parental talk about the importance of science and encouragement to take advanced science classes can make a difference in children's science literacy development (Smith & Hausafus, 1998). Also of interest is a study by Callanan and Jipson (2001) that focused on science talk among families in museums and at home, indicating that science was much talked about in the sample studied irrespective of parental background. Yet, the content of talk was not always the same in that parents with higher educational backgrounds talked more about science concepts whereas parents with lower educational backgrounds focused primarily on the content of the exhibit. Kopran, Bisanz, Bisanz, Boehme and Lynch (1997) developed structured interviews to assess the nature and scope of children's science activities outside of school. Interviews of parents of young children (pre-school and kindergarten age), attest to their involvement in an array of science related activities at home such as reading science books which led to many questions about science content, watching television shows with a focus on science, engaging in science experimenting, as well as community activities such as visiting zoos or aquariums. Interviews of older children (upper elementary

grades) show similar trends, but with some differences. For instance, the older children spent a significant amount of time in science related activities outside of school. They were engaged more often in science related computer games and also participated more often in structured science activities in the community than the younger children. Overall, the study attests to middle-class students' engagement in a wide variety of science activities outside of school. To what extent such activities are also accessible to children and youth growing up in low-income communities that often lack resources and infrastructures for such involvement is a question I return to.

Other researchers examined ways to develop bridges between students' home culture and school science to increase science literacy development. For instance, Hammond (2001), relying on the funds of knowledge children brought to the classroom, describes a science curriculum that emerged from the integration of community funds of knowledge and the development of a dialogic learning community. Teams of parents, teachers and student teachers participated in a summer institute during which they developed gardening activities, recorded traditional stories that could later be used in the classroom, and cooked food harvested from the community garden — all projects that became a means to bring the community together with the objectives of the school. Simultaneously, the construction of a Mien-American garden house was pursued by some Mien parents and community members together with a local architect. It was a process marked by much negotiation due to conflicting cultural practices, resulting in the eventual decoration of the wall with timber bamboo, some of which was sculpted in astonishing ways by the parents involved. This eventual compromise underlines well the complexity involved in scaffolding the bridging of multiple ways of knowing in ways that then supports learning, a non-trivial task. Hammond referred to the science that emerged from that endeavor as "multiscience" entailing an incorporation of indigenous science, personal science and Western modern science.

These studies point to some of the rich resources and strengths that exist in the family and home environment and that constitute youths' identities as learners and actors of science. When used as a means to bridge into school science, such funds of knowledge may offer some of the youth access to other sciences including school or elite science. At the same time, these studies also all too clearly underline that not all youth have access to the same kinds of resources, opportunities, and cultural science practices. Unfortunately, ethnically diverse youth living in underserved communities are typically the ones who struggle most with access issues in that they are often exposed to little meaningful science in school, and although programs in the out-of-school hours could compensate for that, at least to some degree, the same youth also tend to have less access to quality out-of-school programs. As noted in Banks et al. (2007), "many low-income and racial and ethnic minority communities are plagued by poverty, social isolation, and a paucity of infrastructures to support education and well-being" (p. 15).

Having discussed briefly some of the issues of science learning outside of school, I now look at what happens when youth have a chance to participate and have access to at least some opportunities in their community. I begin with an

exploration of the pertinent literature on science afterschool programs, then garden programs, and end with Math and Science Upward Bound programs. In each case, I summarize the literature on science literacy development in terms of what it may entail for diverse urban youth, diverse given their ethnic, linguistic and gender make-up as well as their position in society and the world of science in particular, as youth living in communities that are poor and that often lack the kinds of resources that we understand as necessary to support science literacy development and entry into the world of science. As is the case for the study of science learning in urban settings in general, the effectiveness of community and outreach programs like the ones examined in this book have been studied most extensively in terms of their outcomes rather than the processes that underlie youths' meaning making of science and identity in science. Whereas outcome studies have been particularly important to ensure continuous funding for many of these programs, they tell us little about the many processes at work when diverse youth are given an opportunity to engage with and in science. Those studies tend to ignore the struggles diverse youth face as they live in multiple worlds and try to construct an identity that is meaningful to them while "playing" with other identities that may make participation in elite science possible. I briefly review some of the pertinent literature in relation to each site, to set the context within which the actual data of the making of science and identity at the margin can subsequently be understood.

CASE 1: WHAT WE KNOW ABOUT AFTERSCHOOL SCIENCE PROGRAMS FOR GIRLS ONLY

> I think it (the afterschool program) is imperative, as a support to parents it is vital, as a support to the children it is vital. Again, because of the socio-economic climate of the neighborhood there needs to be that extra hand. It is that old adage of, it takes a community to raise a child, and I really, really do believe that. When the kids walk through the door it is not just about "Hang your coat up, and wait for your parent to get here", I want them to learn something or to experience something positive. (Director of an Afterschool Community Program, Montreal)

As emphasized in the quote above, afterschool programs constitute a third critical developmental setting for children besides home and school (Halpern, 2002). When exploring the history of afterschool programs, their mission "was largely positive — about protection, fun, exploration, enrichment [and] the making of lives" (Halpern, 2003, p. 155). Yet, the recent "discovery" of afterschool programs as a potential means to offer more academic content to children whom the public school system has failed has led to the school's invasion of the afterschool field (Nocon & Cole, 2006). It led to an ideological struggle about the nature of afterschool programs and their goals — are they there to assist with academic work or should they focus on something very different such as cultural enrichment, youth development, arts education, and other content that has been eliminated from schools given current pressures for high performance on tests (Halpern, 2006; Hull & Schultz, 2002).

In general, research attests to the value of afterschool and community programs in helping youth, often for the first time, "develop a sense of themselves as potent actors in their worlds, as people with skills and expertise and dispositions who can exert control over their educational, social, and even economic futures" (Hull, 2008, p. xv). They offer youth often otherwise rejected by society opportunities "to achieve 'balance' — sure footing and a sense of purpose — in their communities as well as an ability to negotiate different roles in different places — to draw on an array of features to give them several identities, all of which are anchored in a secure sense of self" (McLaughlin, 1993, p. 38). What youth really look for in these community organizations are sustained relationships with adults and a safe, personal and supportive environment that treats them as resources to be developed. Youth reject programs that are there to control them, that see them as at risk, or as in need to being fixed. A positive and agentive sense of self then also often translates into positive relations to schooling, subject matter, careers, and ability. Most important, it underlines well the complementary role afterschool programs can play to schooling.

Studies of afterschool science programs attest to their effectiveness in offering youth a safe place to explore new identities as insiders to science. Given the loose structure of such programs, they can become sites where youth co-opt the science that gets done, making it meaningful and relevant to their lives (Calabrese Barton, 2003), or where science emerges from their engagement in meaningful activities (Rahm, 2002). Effective programs offer the freedom to learn in more comfortable ways through play and action. They are filled with opportunities to discover science through talk and action, while leaving room to integrate everyday understandings and everyday concepts with student's scientific concepts, thereby refraining from the decontextualization of content that curtails meaningful learning (Eisenhart, 2008; Gallego & Finkelstein, 2004). Such programs may also offer youth the opportunity to engage in science in ways that make them feel competent and capable to then use science in ways to bring about local change, as was the case among the youth who turned a vacant lot next to a homeless shelter into a green space to enjoy and bring the community together (Calabrese Barton, 2003; Fusco, 2001).

These characteristics also make them particularly promising for reaching out to underrepresented groups in the sciences, such as women. Given the continuous underrepresentation of girls in science, mathematics, engineering, and technology (SMET) careers, efforts to narrow the gender gap have led to many specially designed afterschool programs, mentoring programs, and summer science programs. As has been well documented, girls have less opportunities in school to engage in meaningful science, to use the tools and equipments of science, and often face a curricula of science that portrays the male elite scientist and hence, a curricula that has little meaning for them (Calabrese Barton & Brickhouse, 2006). Girls also get short-changed outside of school, engaging in fewer science-and-technology related activities than boys for a variety of reasons, such as transport problems, safety concerns, as well as domestic responsibilities that leave them with less time for engagement in science outside of school (Catsambis, 1995;

Fadigan & Hammrich, 2004). Yet, when such hurdles to participation can be overcome, structured community activities outside of school can become a means to help broaden the girls' participation in science (Jayaratne, Thomas, & Trautmann, 2003). For instance, Girls Incorporated, a national nonprofit organization, has served girls ranging in age from 6 to 18 years since 1864, initially offering them a safe space to gather while their mothers worked in factories. They supported the girls' development of job skills, ensuring their success later on in life. Given the recognition of a shortage of women entering careers in science, math, engineering, and technology, Girls Incorporated added a science outreach program in the mid eighties, known as Operation SMART. What unites the many SMART programs is their focus on three E's — exploration, equity and empowerment, and one F — fun! Participation has shown to lead to modest gains in terms of the participating girls' attitudes towards careers in science and gender stereotyping (Nicholson, Weiss, & Campbell, 1994). Other studies attest to afterschool programs' effectiveness in improving girls' self-confidence and interest in science, while also reducing their often sexist attitudes about the world of science (Campbell & Steinbrueck, 1996; Ferreira, 2002). Most important, the programs help girls explore science in meaningful and valuable ways while recognizing their own daily experiences and ways of knowing as resources in such a process (Calabrese Barton, 2003; Eisenhart & Edwards, 2004). Hence, afterschool science programs can serve as "door openers" to the world of science yet do not always do so in a smooth manner given the programs' struggle with limited finances, lack of qualified staff, along with a staff that lacks an equitable voice within the world of science (Davis, 2002). This may be the biggest problem of such programs in that they offer girls with forms of engagement in science that lead to new understandings of science and the world of scientists, yet fall short in offering their girls with opportunities to act upon that knowledge and overcome the power relations that keep them out of certain realms of science. Yet, some research reminds us that even though girls often reject the masculine aspects of science (decontextualized nature of activities, mechanistic views of science and nature, and competition), they do not necessarily reject science per se (Scantlerbury & Baker, 2007).

One may question the extent to which programming exclusively for girls is a solution for making science accessible. Research on single sex science classes suggests that separation does not in itself make a difference in achievement level. Much depends on what happens during science class. Yet, quality single sex environments can offer girls a sense of empowerment and a safe space to ask questions without feeling intimidated while also helping them develop a positive attitude towards science. For these reasons, science afterschool programs for girls only, as the one explored here, may serve some important functions in the lives of the participating girls, offering them with the opportunity to play with identities in science in an environment that is safe and empowering. Fadigan and Hammrich's (2004) longitudinal study of 152 girls' trajectories within and beyond science in relation to their participation in a girls only year-long natural science enrichment program suggests that such programs can make a difference and are also perceived

as doing so by the participants. But such programs have to be of long duration and need to offer girls not only a space to do science, but a place to form relationships with staff who care in an environment that is stable and treats girls with respect, making for a supportive and safe space to be and become in. The identified program in Fadigan and Hammrich's study was housed in a museum while the environmental curriculum entailed fieldtrips to local parks and institutions such as the zoo or the aquarium, along with an overnight stay in the museum that housed the program. During the school year, the girls also met in the museum one afternoon a week and attended monthly Saturday fieldtrips, making it a long-duration program. A second year extension of the program entailed opportunities for paid labor in the museum or laboratory, and the mentoring of new incoming girls. The authors argue that the "immersion into a traditionally upper class institution" — here a natural history museum — offered the girls the opportunity "to become adept at crossing borders, allowing students to become experienced in utilizing the dominant language and culture" (p. 856). Most interestingly, the study found that girls from single-parent households and low-income neighborhoods held very positive and high educational and career aspirations which goes against the negative stereotype often associated with that group of youth. Most of them desired high-prestige careers in medicine and the health sciences although some were somewhat unspecific, simply referring to becoming a doctor. Interestingly, 45% of the girls extended their childhood interest and motivation for science into adulthood as shown through their choice of occupation. When consulted five to ten years after program participation, most noted that the science content learned in the afterschool program influenced their current education and career choices. As other studies suggest, the program helped them develop a curiosity and interest in science, which then translated into much self-confidence as science learners and an active participation in the world of science.

Despite such success stories that offer much insights into girls' doing of science, urban girls still have fewer opportunities than their affluent peers (girls or boys) to participate in quality afterschool programs (Larson & Verma, 1999). Girls also have access to fewer science experiences in the non-school hours than boys and experience more barriers to on-going participation than their male counterparts (Kahle, Parker, Rennie, & Riley, 1993). In fact, ethnically diverse urban girls living in poverty are faced with triple barriers to participation in the world of science — poverty, racism and sexism — barriers that have been studied most often as separate factors. The manner they together constitute science literacy development or lack thereof has only recently gained some research attention (Scantlerbury & Baker, 2007). In sum, the brief review underlines well how sustained engagement with science in afterschool programs is crucial for girls' becoming in and beyond science.

CASE 2: YOUTH GARDENS AND PLANT BASED LEARNING

Recent years have seen a growing interest in youth gardening, with school based gardening programs taking the lead alongside neighborhood and community

grassroots programs and others developed through university outreach programs (e.g., Garden Mosaics, Kennedy & Krasny, 2005), public botanical gardens (Morgan & Hamilton, 2006), or through initiatives of community and youth organizations (e.g. 4-H initiatives; Rahm & Grimes, 2005). Since 1993, the American Horticultural Society also hosts an annual Children and Youth Gardening Symposium, which attracts over 2,500 educators, garden designers, community leaders and children's gardening advocates (Lekies & Sheavly, 2007). It has given much visibility to the youth garden movement. The children and youth garden movement is also driven by a vast array of learning goals, some of which include: 1) school-community building and developing culturally relevant schooling; 2) teaching environmental awareness in relation to food consumption; 3) raising awareness about healthy food habits and nutrition; 4) reaching out to troubled or handicapped youth; 5) engaging youth in intergenerational learning; 6) engaging youth in urban planning and the beautification of their environment; 7) developing farm to school programs; and 8) offering summer farming work programs for urban youth to help them reconnect with nature and become agents of nature. Certainly many other dimensions and types of programs could be noted. In terms of academic content, youth gardens are a means to teach biology, environmental science, environmental awareness and stewardship, ecology, nutrition, sports, mathematics, and arts, to name some content areas. Clearly, gardens are rich contexts within which very diverse opportunities for learning emerge as youth interact with and do gardening work (Rahm, 2002). Through questioning about encounters with new content, youth can become agents of their ways of knowing in such sites. In this section, I begin with a brief summary of the literature pertaining to school gardens before exploring the literature on programs in botanical gardens and community gardens that are relevant to the program explored in this book.

A Brief Examination of School Gardening Programs

The first school gardens appeared in Europe and Australia. In Prussia, school gardens became a law in 1869 and in Australia, the annual school garden conference sponsored by the Australian Natives Association since 1903, became an important force behind their school garden movement (Subramaniam, 2002). In North America, gardening programs for children and youth on school grounds were popular in the 1920's, forgotten about in the 1940's due to changes in curriculum and school space organization, then rediscovered in the 1960's due to the environmental movement (Moore, 1995) and the recognition that instruction should integrate resources beyond the four walls of schools. Initially, school gardens were added in urban schools for aesthetic rather than educational reasons. At the same time, youth gardens became a national movement by 1918 and every state in the US and every province in Canada had a least one school garden making it possible for over one million children to contribute to the production of food during the war period. Yet, the gardens' educational value was never fully recognized and after the war, many school grounds were turned into playgrounds

and places to engage in sports instead. The second wave of school gardens began in 1964 with the US's war on poverty and was later supported by the environmental movement. Due to a Californian's Superintendent's call for a garden in every school in the late 1990's, California now has over 2,000 school gardens, making it probably the leading state (Ozer, 2007).

Early philosophers discussed the importance of using the natural environment as a space for teaching. For instance, John Amos Comenius (1592-1670; cited in Subramaniam, 2002) noted, "a school garden should be connected with every school, where children can have the opportunity for leisurely gazing upon trees, flowers and herbs, and are taught to appreciate them" (p. 2). Later, Jean-Jacques Rousseau drew attention to the importance of teaching children through the real world rather than by talking about it, emphasizing that nature is the child's greatest teacher. Later, Johann Heinrich Pestalozzi and Friedrich Froebel further built on the notion that learning involves observation and doing in the world in which students live. In the words of Froebel , "the school child was no longer considered an 'information receptacle' but rather a 'growing flower'" (p. 3). In the 20th century, Maria Montessori emphasized an education that started with the senses before the intellect and advocated gardens as a means to teach children moral education and an appreciation of nature. Dewey also called attention to gardening as a means to extend education beyond the four school walls and to encourage children to experience the place of farming and horticulture in the history of the human race as well as today. Garden based learning programs have certainly gained in popularity. A white paper prepared for the Partnership for Plant-Based Learning (Lewis, 2002) and a synthesis of garden based learning in basic education by Desmond, Grieshop and Subramaniam (2004) both offer much visibility to the vast array of programs and their educational implications. "Garden based learning" has now become the term of choice, after much discussion among garden educators, to refer to an instructional strategy that uses the garden as a teaching tool.

The educational benefits of gardening have been studied most extensively in the context of school gardens. Studies examining *what* students learn from gardening attest to a positive impact on academic achievement and increases in environmental literacy, whereas positive effects on family and community are notable too. Nutritional programs have shown positive effects in terms of children's awareness and enactment of healthier food choices, while also supporting the development of many life skills (Subramaniam, 2002). Other positive effects have been noted in terms of interpersonal skills and interaction, as well as moral development (Alexander, Wales-North, & Hendren, 1995). Yet other studies examined the effects upon teachers and the Master Gardeners that helped out in school gardens. They underline the manner teachers, like their students, get drawn into gardening and how a garden becomes a space somewhat free of the mandated curriculum and hence, a space in which teachers and students come to enjoy the opportunity to be creative together (Thorp, 2006). A study of the Intergenerational Landed Learning Project shows the ways children and youth develop environmental awareness and stewardship through gardening work at the elbows of adults; and illustrates the

manner intergenerational food-growing may result in positive health practices among the children and adults involved (Mayer-Smith, Bartosh, & Peterat, 2007). Along similar lines, the "Edible Schoolyard" project in California — where the garden is used primarily as a means to produce healthy food for the school cafeteria — shows positive effects in terms of teaching students compassion, patience and self-discipline while exposing youth to sustainable agriculture (Subramaniam, 2002). A review by Ozer (2007), taking an ecological perspective to evaluating the impact of school gardens as a setting for positive youth development suggests that results in the literature are inconclusive. Given the vast range of programs that exist and the diverse kinds of goals that drive their implementation, positive effects are not always forthcoming. There is also the challenge of sustainability of school gardens that depend on a truly committed school community. Overall, when implemented properly, school gardens are a rather cost-effective way to not only create awareness about the cycle of food and nature, but to also feed hungry children.

Some accounts exist of the *evolution of school garden programs over time* and their effects in terms of science literacy and positive youth development. For instance, Thorp's (2006) participatory ethnography of a school garden in a poor urban elementary school takes the reader on a journey of children's and teachers' becoming over time. She underlines the contradictions between gardening and schooling, but also the manner the garden became a space for teachers and students to be themselves, to take charge of their learning and becoming, and to act upon their creative needs as individuals. Youths' questioning, occasioned through gardening also stands out here, as it also did in a summer youth gardening program (Rahm, 2002), and the manner such questioning and "moments of wonder" placed the youth "on a trajectory of inquiry and exploration" (p. 48). Thorp also discusses the importance of produce and products from the garden that the children could take home and that then offered the school with a new means of communication with the parents. Gardening was seen as not "school-controlled" or colored by school, supporting new forms of relationships with the community. It also helped youth share their pride with others and work on self-actualization.

Another example is the Garden Mosaics program that combines science learning with intergenerational mentoring, multicultural understanding, and community action (Kennedy & Krasny, 2005). Four investigations were developed that fit into the summer garden program and that were further expanded upon in the collaborating school through service learning projects tied to the garden: 1) the gardener story which offers youth the opportunity to interview the elders in their community about their gardening knowledge or practices; 2) the community garden inventory which entails an investigative tour where youth can ask questions of gardeners; 3) a neighborhood exploration where the youth try to identify places of nature within their community through photographs and topographic maps; and 4) weed watch which entails scientific investigations of the distribution of weeds in the garden. Some of these activities were then integrated with school science and made public on the garden website. As shown, Garden Mosaic relies on youth participatory program development (Doyle & Krasny, 2003). The BYA Youth

Employment Landscape Program is yet another example of a work program for youth that gives them a voice in making the program what it is (Lawson & McNally, 1995). That program offered youth training in landscaping and gardening, and opportunities to build self-esteem and develop teamwork skills while youth also learned about holding a job in a garden and earned some money.

Studies of *how* children and youth learn in and through gardening are particularly interesting in pointing out the educational richness hidden in a garden that the educational philosophers recognized so well in the past. Gardening makes possible the doing of science in an authentically rich environment (Rahm, 2002). Youth see themselves as workers or gardeners and use science as a means to an end. Studies suggest further that gardening also supports unplanned emergent learning opportunities given youths' active questioning and wondering (Thorp, 2006). Much learning is embedded in simple doing and little talk is needed given the richness in context. Most important, studies of youth gardens have led researchers to appreciate a genre of science learning that is about doing, with a real purpose and a real-world obligation, and a science that is socially constituted and oriented rather than simply task focused (Calabrese Barton, 2007). It has led to a notion of science literacy that emerges from an interface of youth, community, and the doing of science.

A study of science learning in a community-based setting where youth, given their concern about nature and beauty, decided to transform an abandoned lot into a community garden is another example that reinforces such a vision (Calabrese Barton, 2003; Fusco, 2001). Guided by action research, that project grew out of children's questions and experiences with the goal to create a science practice grounded in the world of the participating youth. Youth first talked about issues and concerns they faced daily, and were then presented with some examples of youth development projects in order to gain ideas for the creation of their own. Through some scaffolding by the leaders, a connection eventually emerged from the youths' concerns and action plans with the empty lot across the street as a medium to put some of those ideas into reality. It led to discussions about the use of that space in line with youths' concerns and an important opportunity for the youth to express their ideas and take the lead in realizing them. After some specialists were invited, youth were then able to further transform their ideas and use what they learned from outdoor design specialists and greening experts in making their garden a reality. In turn, the urban planning and gardening project became a means to question what science is and also to put science to work (trying to figure out what would grow where and why, inform visitors of the need to care for the garden and not to litter, etc.). The project was then tested within the larger community through an open-house community day in the garden, organized by the youth, to showcase their work and seek out community-members' support in maintaining and sharing it over time. What this project underlines is the importance of engaging youth in science learning and in offering them the role of givers and co-constructors of their environment for science learning.

In sum, studies of the *what* and *how* of learning in youth gardens have offered important insights into what engagement in authentic science entails. The role of students has also been questioned leading some researchers to refer to them as crucial co-constructors of the learning environments and the science that emerges. Not surprisingly, it has led researchers to reflect on science itself and what science literacy may actually mean when considered in the context of diverse urban youths' worlds.

A Word about Botanical Gardens, Youth Gardens, and Science Literacy Development

Since the garden program I explore here is situated and run by a botanical garden, I try to weave together some of the sparse literature on youth gardening programs in such settings to further situate the study. There are over 2,500 botanic gardens in the world today in "nearly all countries and ecosystems" (Waylen, 2006, p. 6). Their mission is broader than recreation, and typically tied to the local society and its people and priorities. They play a key role in plant conservation and in educating the society about its relation to plants in ways that may ensure a sustainable future. Botanical gardens' primary mission today centers on the promotion of research on biodiversity for human well being achieved through the following areas: 1) improving local healthcare conditions, 2) promoting education in nutrition, 3) offering entrepreneurial opportunities that result in financial poverty alleviation, and 4) reaching out to the community through greening projects among others to improve social benefits.

When exploring the literature on youth gardens in botanical gardens, its origin can be traced to the Brooklyn Botanical Garden in New York. Since 1914, approximately 35,000 children have participated in their gardening programs. Professional development workshops for teachers were also offered (Smith & Hamilton, 2006a&b). The youth gardens put children in charge of cultivating a garden plot and through hands-on activities and inquiry diverse horticultural skills were developed. That garden program became a model for many other botanical gardens. A study of the garden programs' alumni underlined its lasting impact to participants in that all of the alumni could recall experiences from their participation in detail. Many of the participants maintained a strong interest in nature and public gardens, and 78% of the respondents felt their involvement today was due to their gardening experiences as youth. Most were also positive about their past gardening experiences (86%) and the study suggests that the hands-on activities allowed students to learn lasting gardening concepts and skills. Self-esteem also appeared bolstered through participation, in part due to the growth of their own plants, and as a result of friendships that emerged, while gains in personal and social skills were also noted. Participants also showed heightened environmental awareness. For some participants, the program exposed them to new career options, contributing to 17% of them eventually pursuing professional careers in horticulture. Participants also saw themselves as key components that made the program successful.

A study of Project Green Reach's summer youth gardening program, a new outreach program at the Brooklyn Botanic Garden targeting youth living in poverty, shows similar positive effects in terms of academic gains and the development of interdisciplinary skills, increased levels of understanding of science concepts, of gardening knowledge, environmental awareness, and appreciation of nature (Morgan & Hamilton, 2006). More recently, a Garden Apprentice Program for youth ranging in age from 13-15 years was put in place at the Brooklyn Botanic Garden, to attract older youth and also expose them to careers in the environmental field and in the plant sciences (Myrie & Arnone, 2006). During the first year, interns work at discovery carts in the botanical garden, the second year they are placed in the Education, Science, Horticulture or Library departments, and in their third year, they assist the garden staff with gardening, teaching, and managing of student groups. In their fourth year, they lead groups in the Children's Garden, assist discovery guides and mentor the juniors of the apprenticeship program. Overall, the program is meant to offer 75 internships.

The brief summary presented here offers some flavor of the kinds of opportunities that are supported by botanical gardens. Studies of school gardens, community gardens, and youth gardens in botanical gardens all attest to a rich learning environment that supports meaningful engagement with science and offers opportunities for youth to connect with their environment and become its stewards.

CASE 3: UPWARD BOUND MATH-SCIENCE PROGRAMS, AN EXAMPLE OF A UNIVERSITY OUTREACH PROGRAM

The third site, a Math and Science Upward Bound program, figures prominently in the landscape of university outreach programs in the United States today. They also have a long history. Upward Bound programs are a result of the economic opportunity act signed by President Lyndon B. Johnson in August in 1964 and the administration's "War on Poverty", authorizing 18 pilot Upward Bound programs in 1965, and growing to 220 programs during the following year. The Talent Search program was set in place also in 1965, furthering youths' potential success in higher education. In 1968, the term TRIO was coined to subsume the three initial programs – Upward Bound, Talent Search and Student Support Services (SSS), the latter assisting undergraduate students in their completion of postsecondary education. In 1972, the Veterans Upward Bound was created to respond to the needs of Vietnam veterans in transition from military to postsecondary education and in 1972, the Educational Opportunity Centers Program was put into place to serve adults, while in 1986, the Ronald E. McNair Postbaccalaureate Achievement Program followed suit to prepare undergraduates from groups underrepresented in graduate education to pursue a Ph.D. degree. Today, seven different programs make up the TRIO project (including the ones described), with the mission to help students overcome class, social and cultural barriers to education.

The Math and Science Upward Bound Programs (UBMS) were established in 1990 to strengthen the math and science skills of the participating students, and to

encourage them to pursue postsecondary degrees in math and science (Olsen et al., 2007). The programs target students between 13 and 19 years of age, having already completed eight grades of elementary/middle school. The initiative began with 30 programs but has grown to 127 programs serving 6,845 students at a total cost of $32.8 million in 2004, most being hosted by four-year colleges and universities (Olsen et al., 2007). In essence, they are part of a diverse array and rich infrastructure of science outreach programs held in university research facilities. UBMS programs are typically funded to serve 50 students who are either living in poverty and/or are the first generation in their families to be college-bound. In years 2000-1, 75.2% of the participants in the programs fit both the low-income and first-generation eligibility status (Curtin & Cahalan, 2004). When examining the ethnic profile of participants, African American students were the largest group at 40.7%, followed by white 24.8%, Hispanic or Latino 19.8%, and Asian, 7.4%. Interestingly, about two-thirds of the participants are female. UBMS programs must offer an intensive summer residential or nonresidential component in addition to services in counseling, academic advising, and tutoring. Four other characteristics define such programs: 1) intensive hands-on learning opportunities in mathematics and science; 2) opportunities to interact with mathematicians and scientists; 3) activities at the elbows of graduate and undergraduate students in math and science; and 4) access to some university coursework.

The first report commissioned by the U.S. Department of Education on program performance offers a profile of the UBMS Program in the years 2000-2001 (Olsen et al., 2007). Two evaluation reports followed, the first being accessible to the public, documenting impact estimates inferred from participant surveys and academic transcripts of a sample drawn from program year 1998-1999. The study used a matched sample design which made possible the documentation of program participation effects such as improvement in high school grades in math and science, increased likelihood in taking upper-level science courses, increased likelihood of enrolling in selective four-year institutions, increased likelihood of majoring in math and science, and also a higher likelihood of completing a four-year degree in math and science. It led the authors to conclude that participation in UBMS programs has improved some students' outcomes in high school and college. Research on general Upward Bound Programs without a particular focus on math and science show a positive impact primarily for students who at the time of application did not envision pursuing a college degree (MPR, 2004). Franklin (1984) suggests that Upward Bound does support the development of economically disadvantaged students' academic and socio-cultural skills, something that the UBMS programs most likely support too. Yet, the development of such capital does not necessarily have an effect on participants' high school preparation or grades but results in a positive effect in terms of students' college enrolment. The educational attainment overall is higher for Upward Bound students as compared to others who did not participate (MPR, 1997). Participation in the program has an incremental effect and hence, students who are able to participate for the three consecutive years are the ones who benefit the most (McElroy & Armesto, 1998). Furthermore, Upward Bound programs are most successful when supplemented by

other programs, initiatives, and opportunities during high school as well as on-going support once in college through other TRIO programs. Studies of program impact on parents show that they help in demystifying the college application and procedural aspects (Zulli, Frierson, & Clayton, 1998).

Little research has examined what happens inside Math and Science Upward Bound programs. An exception is a study by Rodriguez, Jones, Pang, and Park (2004), that describes the effects of a year-long university outreach program – an enrichment program for tenth-graders. Rich descriptions are offered of the manner the program supported the development of students' math and science skills while also promoting the positive personal development of students. The program became a space where students felt safe to explore mathematics and science. Participation also led to feelings of empowerment and increases in self-confidence, which in turn, supported active participation in the learning experiences offered. A study by Scales et al. (2005) examined urban youths' development of assets through participation in school-business partnerships. They identified three types of scaffolds students received through such programs and the effect they had on students' educational resilience. The first kind of scaffolding, termed "providing for", simply offered students resources but little personal coaching. The second type, "side-by-side", entailed more personal interactions with adults who encouraged youth to pursue an education. The third, "student engagement", was most promising in that it offered students the opportunity to seriously examine their beliefs about education and to question their own position in relation to education and society through dialogue with the adult mentors. It left students with an "I will" and "I can" attitude and greatly supported their future success. The latter type of interaction can also be found in quality Upward Bound programs that are sought out and valued by youth such as the one I describe here. Knox, Moynihan, and Markowitz (2003) remind us that such programs may offer youth a means to be with like-minded ones who are interested in science, an interest that is often "unpopular" and therefore has to be hidden in school.

Although Math and Science Upward Bound Programs are similar to other university outreach programs, or even some of the other afterschool science programs I discussed, in that they offer youth engagement in hands-on science activities, they are also charged with offering youth opportunities to engage in science at the elbows of graduate students and scientists in their third year. The literature on mentorship programs not part of Upward Bound per se but similar in structure underline their positive impact in terms of the students' understanding of the nature of science and scientific inquiry, as well as their role in sparking the students' interest in science and opening the participants' eyes to the many career possibilities in science (Bell et al., 2003). Similarly, studies of interactions among youth and scientists underline the ways such interactions along with guided reflections, can lead to a deeper understanding of science and scientists' work (Rahm, 2007).

Some researchers have also looked inside mentorship programs where students get to work alongside scientists during a summer camp or school year. This line of research has examined the kind of science that gets done as well as the challenges

such programs face in terms of "undoing" narrow notions of science that often impede students' full participation in scientific investigations at the elbows of scientists (Barab & Hay, 2001; Bleicher, 1996). For instance, Richmond and Kurth (1999) highlight students' frustrations about projects that do not work, which often happens in the real world of scientists, but is rarely experienced by students given the "cookbook" laboratory exercises that too often define their engagement in science at school. Engaging in "real" science can also be labor intensive. In particular, data collection can be repetitious and tedious and potentially appear as "slave work." Yet, such work is necessary for producing data that can be used as solid evidence for claims that are put forth. Often, scientists, like teachers, assume that their apprentices learn by doing, and forget that it is necessary to talk about the form science engagement takes – a strategy that could have alleviated the frustration students felt when engaging in labor intensive aspects of science. Bell et al.'s (2003) study underlined that little talk focused on the general attributes of science. Instead, most focused on the particulars of the projects and hence, undermined the educational potential of such partnerships. If apprenticeships are used as a means to challenge students' notions about the nature of science and scientific inquiry, targeted reflection about these particular components is necessary. The authors refer to Dewey and his call for doing, but also reflecting about such doing if it is to lead to meaningful learning.

Apart from the importance of emphasizing reflection about science, time or program duration has emerged as another important factor. For instance, Barab and Hay's (2001) study underlines well the limits of a two-week apprenticeship program in which students lacked the opportunity to get fully engaged in the science they were doing. Other studies show that students who are not involved in the development and planning of their research questions and projects due to time constraints may struggle grasping the meaningfulness of their projects and actual work at the elbows of scientists (Bell et al., 2003). On the other hand, Ritchie and Rigano's (1996) study underlines that lack of involvement in the development of the projects can lead to a brick wall initially, a challenge that can be overcome to some degree with time, however. Ritchie and Rigano's high school students worked up to six weeks on a project at the participating University one afternoon a week, and with time, came to own the projects, eventually feeling empowered.

Some studies suggest that science work in the community and at elbows of scientists is only valuable if it is somehow brought back to the classroom or when it is about "connected science" (Bouillion & Gomez, 2001). In their project, students became engaged in a scientific investigation — problem of pollution of a nearby river — that was real, and scaffolded by the community through a school-business partnership. Once the teachers and students had identified the problem to be investigated, they looked for a business as a partner, referred to as the client, while the students were the consultants for the project. Through collaboration with other community constituencies, the project evolved over time into an activity that was situated within the immediate community and led to some social action — the beautification of the environment through the restoration of the riverbank to which students and the community contributed in different ways over time. Most

important, through such a project, students were exposed to atypical identities in science. They learned about people involved in stewardship and through education, investigations, and community improvement engaged in the protection of the environment. Other examples exist of such partnerships that start in the classroom and bring the community in through changes in the social arrangements and structure of schooling. In such programs, students no longer work at the elbows of scientists as apprentices but instead, work *with* scientists, businesses, and other key players in the community to resolve an issue of scientific significance that is meaningful to all of them. Bruce, Bruce, Conrad and Huang (1997) summarize yet another form of partnership, the kind where graduate students come into classrooms to do science with youth, bringing with them much science expertise, equipment and materials that then make for richer learning experiences. They argue that such interactions may be more effective than interactions among scientists and youth, since graduate students are good role models and more accessible to the students than scientists given their age and presence in the classroom over time.

As shown, work that is done at the elbows of scientists in summer programs as well as partnerships between schools and scientists over time all aim to make science more accessible and meaningful to the participating youth while also attempting to offer them with new visions of science and identities as insiders to science. They have done so with some success. Later on, in chapter 6, we will see how this played out in an Upward Bound program that offered diverse opportunities to youth to interact with scientists, by visiting them in their workspaces through a job shadowing experience, and by working at their elbows during their last program year, the component I focus on in this book.

CONCLUSION

When discussing out-of-school programs, a distinction should be made between "increasing engagement in learning" (or in science) versus "directly improving academic achievement" (Pittman, Irby, Yohalem, & Wilson-Ahlstrom, 2004, p. 23), a distinction often forgotten, especially in the current climate where the afterschool programming field is often charged to make up for lost academic content. Or as Halpern (2006) put it, a distinction between academic and life-long learning, the latter being at the core of afterschool and community programs. Yet, "blurring the lines between the kinds of learning opportunities young people have, the kinds of content embedded in those learning opportunities, and the settings, in-school and out, where that learning occurs, can ultimately benefit young people and society by increasing the relevance and continuity of their experiences" (Pittman et al., 2004, p. 38). In fact, there is a correlation between engagement in learning and long-term academic success, even though the relation between the two is not a direct one. What afterschool and community youth programs have done well in the past is to engage youth in learning and thereby support positive youth development (Mahoney, Eccles, & Larson, 2004).

As the review of the literature attests to, some of the programs engage youth with science in ways they never had an opportunity to experience elsewhere. They offer new ways to relate to science, to play with insider identities in science, and to explore science in rich and meaningful contexts that are linked to who the youth are and are becoming. In many instances, they also offer youth the opportunity to develop real competence in science. Yet, as Calabrese Barton and Brickhouse (2006) caution, "not all forms of engagement with science lead girls to gaining access to science and science-related communities" (p. 224). As will be shown, the same can be said about the youth in this book, given the manner power plays out in the acquisition of science literacy. For instance, gardening may lead to much scientific knowledge useful for improving ones living conditions and our planet; however, such ways of knowing would not necessarily translate into insider status in school science and access to higher education. Even in the case of mentorship programs that offer rich opportunities to engage in truly authentic science practices, it is not clear to what extent they act as door-openers and entry points into the standard science trajectory.

Although it may be particularly useful to think of afterschool and community programs as intermediary spaces, representing a new social space that is not school, home, or the streets (Noam, & Tillinger, 2004), and hence, as places and practices of science that are qualitatively different from others, it is not clear yet, what role they really play in youths' science literacy development. Will they lead to knowledge they then act upon as adults and informed citizens? Or do they offer yet another illusion of insider status to science that is lost once youth move on in life? Turning now to the theoretical framework of the study, and in turn, to the data, some answers should come forward to such complex questions.

THEORETICAL POINTS OF REFERENCE

> Understanding development from a sociocultural-historical perspective requires examination of the cultural nature of everyday life. This includes studying people's use and transformation of cultural tools and technologies and their involvement in cultural traditions in the structures and institutions of family life and community practices. (Rogoff, 2003, p. 10)

To describe the cultural nature of youths' everyday lives in the three settings studied, adapting Rogoff's words, is the primary objective of this book, a focus that emerged over time. In fact, the theoretical frameworks and disciplines that informed the study attest in many ways to my own trajectory as an educational psychologist that has been far from linear. As an educational psychologist with a background in developmental theory, I am primarily interested in the study of learning and development, processes I take to be constituted by the learners' identity work in practice. I conceptualize the learning of science as a form of engagement in cultural practices and as constituted by the participants' positioning in science and beyond. Although such a focus emerged from my reading of sociocultural-historical theory and activity theory, it was also influenced by the literature on positive youth development, learning in museums, afterschool and community organizations, and literacy studies, as well as some of the discursive studies of meaning making of science. In this section, I offer the reader with brief summaries of these theoretical approaches to ground the chapters that follow.

THE STUDY OF LEARNING AND DEVELOPMENT OUTSIDE OF SCHOOL

The manner I approach the study of learning, development, and positioning emerged from my grounding and understanding of the cultural-historical approach to learning and development, as well as activity theory. These theories, having their roots in the work of Vygotsky, Luria, and Leont'ev, have been further developed by current proponents such as Cole (1996), Engeström et al. (1999), Rogoff (2003), Wells and Claxton (2002), Wertsch (1991), to name a few.

The approach takes for granted that teaching and learning occur naturally as humans interact, use, adopt, and transform cultural tools that mediate their actions. Learning and development are conceived of as a joint activity rather than individual properties, and its study entails an examination of the social practices that the individuals are engaged in. Important is also the recognition that culture cannot be separated from individual's everyday practices but instead, is part of it,

making the study of how people live culturally the primary objective (Gutiérrez & Rogoff, 2003). Hence, the three practices explored in this book are each understood as socioculturally organized practices. Each setting has its cultural norms and values that constitutes its forms of engagement and identity work in science which are continuously made and re-worked through social interaction among its members and hence also socially mediated. It follows, that focus rests on the *process* of learning and youths' engagement with science rather than its product. In essence, "Vygotsky insisted that in order to understand the mature human mind, we must comprehend the processes from which it emerges. … [The] human mind must be understood as the emergent outcome of cultural-historical processes" (Daniels, Cole, & Wertsch, 2007, p.1). It led to an interesting wave of studies on the cognitive aspects of everyday mathematics that inspired my initial exploration of everyday science in the making. For instance, the seminal studies by Lave (1988) of adults' engagement with mathematics in the supermarket or during a diet made visible its embedded nature in on-going activity and the manner it was inseparable of a persons' engagement in an activity. In both cases, mathematics was invoked as a means to an end and became a resource for action (the decision to buy a grocery item or not; to decide on the most efficient procedure to measure quantities while respecting diet guidelines). Since mathematics was invoked as a tool for action, however, it was not as visible. Interestingly, science tends to be embedded still deeper in everyday activities, making its study even more challenging. For instance, when exploring an inner-city youth gardening program (Rahm, 2002), youth described themselves as workers in an entrepreneurial gardening program and did not perceive themselves as being engaged in science. For one, scientific knowledge was invoked as a tool for action and hence, embedded in a richly textured practice making it invisible to them. At the same time, their own notions of science were very narrow and tied closely to their experiences with school science, making the science in gardening invisible to them for yet another reason. Despite the "hidden" nature of science, research suggests that we engage in and with science continuously outside of school. To give an example, Ochs and Taylor (1992) explored family dinner conversations and underlined the ways these conversations offered a testing ground for engagement in scientific argumentation and helped children appropriate such ways of talking science.

What the studies on everyday cognition and science underline, and that is pertinent here, is the fact that to understand meaning making of the science and science practices I describe in this book, focus has to rest on the kinds of learning opportunities that *emerge* due to youths' interactions with the tools, resources, and each other as they are engaged in science activities. Furthermore, their histories as learners, their current positions and possible future selves have to be taken into consideration too, constituting in yet other ways their engagement in the goal-directed activities of the three science practices I explore. Finally, the practices are best understood as the *source* of science literacy development rather than simply as a setting or its context (Vygotsky, 1994; emphasis added). I "conceive of individual and environment as factors that mutually shape each other in a spiral process of growth." Yet, "what constitutes the environment is to a large extent

dependent on the child" (Van Der Veer, 2007, p. 22). For instance, gardening may mean many different things to different youth depending upon their histories, yet also their level of engagement within the garden. Whereas the physical environment differs for each child, the same can be said for the social environment that also changes as the child develops. It attests to the complexity inherent in understanding learning and identity work from such a perspective. It is a complex dynamic process, having its roots in a dialectic among subject and environment.

What also attracted me to sociocultural-historical theory is its acceptance of lived experience as a source of knowledge (Gonzalez, Moll, & Amanti, 2005). It is taken for granted that learning and development at home, in the community, and in schools are tightly interconnected and constitutive of learning and positioning work (Gutiérrez & Correa-Chavez, 2006). Learning is "situated in broad socio-economic and historical contexts and is mediated by local cultural practices and perspectives" (Banks et al., 2007, p. 5). In fact, Vasquez (2006) reminds us that sociocultural-historical researchers started by examining the outside world and its role in educating minds before turning to classroom studies given the premise that the mind is constituted by culture and social context. Yet, for most studies on everyday cognition, "school was the implicit comparative structure from which behavior and culture were judged" (p. 45). It led to a vast literature on learning tied to particular locations and the adoption of a dichotomy between formal and informal learning. These ways of defining learning in terms of its location then took on a life of its own, leading to distinctions among formal, nonformal, and informal learning (Bekerman, Burbules, & Silbermann-Keller, 2006). Yet, practice theory and sociocultural-historical theory remind us that schools are simply one among many social institutions and practices where children, youth and adults spend time and that contribute to literacy development. It has led to a new appreciation of the complexity and diversity of practices that constitute youths' learning and becoming. It has also led to the challenge of understanding diversity not in terms of youths' deficits but in terms of who they are in society and the kinds of practices they have access to, seek out and engage in within their communities (Gutiérrez & Rogoff, 2003). Maybe most important, it has helped move the field beyond blaming youth for knowledge they may be lacking towards a focus on the manner youths' science literacy emerges from participation in culturally mediated, historically developing, practical activities.

Such a perception of youth is also central to the New Literacy Studies which led to compelling stories and rich descriptions of the diverse kinds of literate activities children, youth and families engage in outside of school and that constitute who they are and are becoming (Hull & Schultz, 2002). Such work emphasized in important ways how everyday literacy practices are tied to learning, doing and becoming outside of school. New Literacy Studies (NLS) has also made evident the ways schools impose a literacy of power on the outside world, which then justifies the ignoring of the kinds of everyday literate practices that define so many outsiders to that system of power. The questions NLS has raised of whether school literacy is the only form of literacy practice has made possible the study of literacy development as a situated process in and outside of school. In essence, the NLS

approach justified the study of learning and development outside of school in its own right, without constantly having to compare and contrast it with school learning. Recent studies on youths' engagement in creative practices outside of school and in particular, in terms of work they pursue on their own terms outside adult sanctioned spaces, make a strong case about their importance in informing classroom teaching and learning and the manner they may become embodied within school practices (Gustavson, 2007). Most important, NLS offered me a theoretical lens to describe the meaning making of science in each site in its own ways, making possible the highlighting of its unique characteristics such as its own ways of talking, thinking, acting, and interacting (Kelly, Chen, & Crawford, 1998).

This brings me to the literature on positive youth development often evoked when discussing community youth programming. That approach emerged in response to the medical and deviance model that historically informed studies on low-income youth and families, focusing on their maladaptations, incompetence and deviance. Today, positive youth development is an umbrella term for many things. What is most important is its primary focus on youths' potentials rather than incapacities. It takes a strength-based lens to the study of youth development. Community is taken as central to youth development but also youth agency. It is assumed that positive youth development is more likely when youth are embedded in relationships, contexts, and ecologies that support and nurture their development. Although often forgotten, the approach takes serious the fact that "youth are major actors in their own development and are significant (and underutilized) resources for creating the kinds of relationships, contexts, ecologies, and communities that enable positive youth development" (Benson, Scales, Hamilton, & Sesma, 2006, parenthesis in original, p. 896). Despite much research on youth from an assets perspective, it still follows in the shadow of the literature focused on a problem perspective (Delgado, 2002). Yet, I was highly influenced by the wave of studies on community-based organizations (CBO's) across the United States, by Heath and McLaughlin, in response to the stronghold of the deficit perspective that kept guiding policy makers, politician's talk, as well as many practices in school and beyond, and that led to the mushrooming of prevention programs. Their study of approximately 120 youth-based organizations over the past ten years within 34 different cities in the US led to many valuable insights about "effective" community based-organizations, a study that relied in part on youth to define those terms (Heath & McLaughlin, 1993; McLaughlin, 2000). The institutions judged valuable by youth drew on the youths' strengths while learning was emergent and unpredictable rather than controlled or imposed. The youth did not feel invisible in those spaces but instead were looked upon as making them work, which led to a sense of personal value, hopefulness and agency. Arts based community programs, especially those that counted on intense collaboration among its actors to work towards a major production, are also effective in "blurring the lines of racial and ethnic division and crossing linguistic barriers" (Heath, 2001, p. 16). Diversity is an asset. It underlines some of the complexity and multi-layered ethos that make such places productive in the eyes of youth. Although learning is certainly multimodal, complex and embedded in achievement and much

responsibility, flexible problem solving on part of the youth also make such programs work. Similar arguments were also forthcoming by sociologists and anthropologists that explored youths' ways of carving out spaces of significance in and beyond school or what they referred to as safe spaces (Weis & Fine, 2000). Rejecting a look at the formal-informal dichotomy of learning, their work focused instead on spaces where youth spent time and that they carved out for themselves since they offered them opportunities to engage in learning that they judged valuable and meaningful.

These lines of research all offered different, rich insights into learning beyond schooling and informed my exploration of engagement and meaning making of science in three different cultural practices at a time when such work was still marginalized by schools of education. Delgado (2002) introduced the term "new frontier settings" to refer to community sites that have education as their primary objective yet also lend themselves simultaneously to programming for youth. I would argue that all three sites studied in this book fit this category. The programs shared a focus on science literacy development, defined in broad ways, but also put much effort into "mobilizing youth to shape their contexts and communities" (Benson et al., 2006, p. 898). To summarize, sociocultural-historical theory, research on positive youth development, having its roots in sociology, anthropology and community activism, along with the New Literacy Studies and ethnographic studies of spaces beyond school by sociologists, anthropologists and feminists, led me to explore science in the making outside of school in the ways I eventually did.

THE STUDY OF MEANING MAKING OF SCIENCE

In line with sociocultural-historical theory, I wanted to understand how diverse urban youth, often for the first time, do science when given the opportunity. I wanted to understand what doing science and meaning making of science looked like in the three sites studied, the form it took, and how science was talked into being through interaction with each other and artifacts of science. I also wanted to understand how youths' own relation to science and position in science came to constitute learning and further becoming. To do so, I first offer a description of my assumptions and unit of analysis.

I take for granted that children and youth are genuinely interested to make sense of their situations and to create their own understandings when engaged in meaningful science activities — a process I refer to as meaning making of science. Simultaneously, I assume that learning is about building knowledge together with others and as one interacts with textually rich contexts. Yet, such learning then entails a "passage from social contexts to individual understanding" since "we first meet new ideas (new to us, at least) in social situations where those ideas are rehearsed between people, drawing on a range of modes of communication, such as talk, gesture, writing, visual images and action," interactions that make up the social plane in Vygotskian terms (Mortimer & Scott, 2003, p. 9). Yet, that social plane and its "social tools for communication" then need to be internalized and

become one's own. Hence, meaning making needs to be understood as a dialogical process among people and between people and artifacts. Ideas are made, contested, and reconstructed and made one's own through internalization, which in itself is a meaning making step if we are to highlight the fact that meanings are never passively absorbed but actively made and constructed. Words never carry meaning but instead, "are inevitably polysemous, acquiring different shades of meaning as the context of usage changes" (p. 11). Accordingly, I use the term meaning making in this book to highlight the fact that it is a dialogic process and always about "bringing together, and working on, ideas" (p. 11). As such, meaning making is one of the most fundamental activities of human beings.

In line with activity theory and the sociocultural-historical approach to development (Leont'ev, 1979, 1981), I take for granted that such meaning making is mediated by artifacts and hence, the artifact-mediated action is the primary unit of analysis. Accordingly, I study the activity and the tools the youth invoke as they engage in science in the different sites to make meaning of science and of themselves in relation to that activity. Such an approach to the study of science literacy development has come to frame some classroom research, leading to rich descriptions of ways science is interactionally accomplished through work by students, teachers and also through tools that are invoked in such a process (Kelly et al., 1998). It is assumed that science is talked into being through interaction, action, and talk whereas the learners' prior understandings of science and the scientific speech genre contribute to such in important ways.

Building on that, I argue that a focus on activity (e.g., participation in an afterschool science program), also prompts the study of intentionality and purpose behind actions in that activity. Participation is understood as being tied to its motive (e.g., to be with friends, to learn more science, etc.). As noted by Leont'ev (1979) "the actions that constitute activity are energized by its motive, but are directed toward a goal" (p. 60). To offer an example, I may participate in a science program given my goal to become as science literate as possible, something I try to achieve through goal-driven-actions within the program such as the participation in a science fair project on a topic of my choice, driven by the motive to learn more about something that may eventually help me become a certain kind of person (overall goal). In the words of Leont'ev, "the means by which an action is carried out [are] its operations" (p. 63). In this example, the operations may entail the searching of scientific information in books, on web sites, as well as the construction of science through social interactions with peers. A study of motives and goals can explain why youth participate and enroll in programs, yet also how participation is experienced and the actions that are taken. In turn, the kinds of opportunities that are sought out within a program constitute in important ways the role such programs come to play in the lives of the participants. In sum, some need always drives an activity. And it is this kind of need, motive and goal that I try to explore here since I consider it an important part of learning and development. Yet, motives for participation need to be understood also in terms of how the learner positions him or herself in relation to the activity. We need to understand why and how youth engage in science in different settings, how science is talked into being

in such sites and made through action and interaction, and what such tells us about learning and becoming in relation to science over time

The activity itself is the science discourse that students engage in. Discourse here is understood as "a socially and culturally produced way of thinking and knowing, with its own ways of talking, reasoning, and acting; its own norms, beliefs, and values; its own institutions; its shared history; and even its shared mythologies" (Rosebery, Warren, & Conant, 1992, p. 65). Like others, I focus on the discourse of meaning making of science and explore youths' engagement in science practices over time (Crawford, Kelly, & Brown, 2000). In doing so, I assume that *talking science* implies not simply language per se, but doing something with words (Lemke, 1990). Hence, language is a resource for meaning making in that one may use grammar or semantics in purposeful ways to get a point across. Yet, talking science and meaning making also entails more than language per se. Focus has to also rest on the multiplicity of modes of communication or what has been referred to as *multimodality* (Jewitt, 2008; Kress, Jewitt, Ogborn, & Tsatsarelis, 2001). I assume that there are many modes whereby understandings are made and conveyed, in addition to language and written text. I take for granted that meaning making is stretched across images, gesture, gaze, body posture, sound, writing, music, speech (metaphors, analogies) and so on. Those modes are interwoven, fluid and ever changing, while being invoked to meet particular needs or motives of the moment, and hence, meaningful within that particular context at that time. The modes themselves are taken as partial, each contributing to learning in its own way yet always in conjunction with others. It follows that each practice that I study here may have its own and unique configurations of modes of communication. In some practices, speech may be more salient than action, whereas gaze and gesture play a bigger role in other contexts. It has been suggested that science may be particularly challenging given its *multimedia* literacy demands (Lemke, 2000). When science is made or conveyed, scientific concepts are typically articulated across different media of representation such as technical verbal language, mathematical, graphical, diagrammatic, pictorial, and many more modalities of representations or inscriptions. Sometimes, inscriptions are also simply talked about yet physically absent, which further complicates meaning making for newcomers. A focus on the making and use of inscriptions rather than representations per se leads to an examination of its making as a social activity rather than its mental abstraction (Roth & McGinn, 1998). Accordingly, meaning making of science is also about youths' appropriation of ways of talking and representing science particular to each practice, about the ways to embody, construct, and articulate science across graphs and tables. Meaning making of science can also entail much work with scientific texts, which are multilayered in meaning and often need to be translated before they can be appropriated. How such translating and appropriation happens over time as the youth are engaged in science is of particular interest.

As suggested, it would be elusive to study meaning making out of context and as removed from its visual images or the situational context of the activity. Yet it is also important to remember that broadly defined, language has two functions in

life: it is a resource for conveying meaning but also a tool to make meaning. Its study helps us understand what "people can mean, and how they use their linguistic resources to do so" (Wells, 1999, p. 6). The two are constitutive of meaning making and learning and essential components of the study presented in this book.

YOUTHS' POSITIONING IN SCIENCE: LEARNING AND BECOMING IN AND THROUGH SCIENCE

Taking the sociocultural-historical approach still a step further, I explore the dynamic, socially and culturally constituted nature of learning and identity development over time and space in science in settings at the margin. Although Vygotsky is seldom talked about in discussions of identity, he did write on self and personality which offers some important groundwork for the manner I use positioning in this book. Mead like Vygotsky, perceived "self as a complex emergent phenomenon, continually produced in and by individuals in their interchanges with others and with the culturally transformed material world" (Holland & Lachicotte, 2007, p. 104-105). Both Mead and Vygotsky also focused on the ways social interactions, mediated by symbolic forms, constituted identity work, offering rich resources but also constraints for its formation. In the words of Vygotsky, "an *identity* is a higher-order psychological function that organizes sentiments, understandings, and embodied knowledge relevant to a culturally imagined, personally valued social position" (p. 113). Such identities then mediate action in cultural worlds whereas such actions further transform and constitute identity work, underlining the dialogic quality of the self. It is taken for granted that "identities, the cultural worlds that ground these senses of self, and the discursive and practical activity of positioning that realize them, pervade the social contexts of politics and social change" (p. 127). It is also important to recognize that even though we may have multiple selves, there is some level of integration and coherence among them. Yet, as individuals, we play with positions that are in our cultural world by joining in, opposing, and transforming; eventually producing personal variants that make sense to us. As such, positions are always appropriated and made our own, and never taken up as is. It is this dynamic behind the social and psychological of positioning that Vygotsky's work underlined and that informs the approach taken here.

I take for granted that we are continuously positioned by our culture and history in certain ways, yet what interests me most is what the positioned do with it, their creativity in forming subjectivities that then come to mediate subsequent actions (Holland & Leander, 2004). It is this kind of work that I refer to as positioning, as it has been used by others guided by anthropology and practice theory. I take positioning to be a regular feature of interaction. And as such, I take identity work to be about the authoring of selves in practice and hence, about the *positioning of self*, understood as constituted by ones' history and current membership within a community of practice, as well as the power relations in society. Thus, "positional identities have to do with the day-to-day and on-the-ground relations of power, deference and entitlement, social affiliation and distance — with the social-

interactional, social-relational structures of the lived world" (Holland, Lachicotte, Skinner, & Cain, 1998, p. 127). It is about a person's identity work in a lived world. Such constructions or authoring of self entail agency and are simultaneously understood as being constrained by the societal structures within which the youth find themselves. That is, certain ways of positioning may allow for new ways of being or new positions or identities to emerge, attesting to agency. And in line with a dialogic view on identity work, identity "is 'worked up' from 'both available identity resources and the contextual constraints of the use of these resources" (Tan & Calabrese Barton, 2008, p. 45). Some of the youth I describe in this book may have come to see themselves as youth living in poverty who do not have access to quality education because of such. That notion is challenged, however, given their participation in a quality program in which they are respected for who they are, making the kind of work behind opposing identities evident. In essence, I will show how the youth "draw on different cultural resources and structures and recast and transform available and organized social positions to shape their subjectivities" (Holland & Leander, 2004, p. 131).

Positioning is about the interplay of agency and structure but also constituted by the youths' histories and figured worlds – the kinds of meanings the youth have constructed of their worlds given their past and current experiences. These figured worlds are continuously re-constructed through new experiences with science, and in turn, come to support new possible selves, underlining the dynamic nature of identity development and experience. In some sense, the figured worlds are what some researchers might have termed prior understandings when exploring learning and development. They also include the history of the individuals. Yet, the way I use the term figured worlds here accounts to more. Most important, it underlines the constructions each individual makes over time of self, the higher psychological meanings that are internalized and come to constitute who we are and are becoming. As Holland et al. (1998) underline, "a figured world is formed and re-formed in relation to everyday activities and events that ordain happenings within it" (p. 53). "These collective 'as-if' worlds are sociohistoric, contrived interpretations or imaginations that mediate behavior" (p. 52). They become "the contexts of meaning and actions" (p. 60). That is, youths' figured worlds about science, scientists, and themselves in relation to science constitute learning and becoming in the programs explored here, whereas participation will simultaneously lead to the emergence of new re-constructed figured worlds, a dialectic at the heart of learning and becoming across space and over time.

Finally, I take positioning in the world of science to be hybrid. In doing so, I allude to the agentive part of youth in identity work, yet also to the multidimensional nature of identity work when approached from a truly dialectic stance (Roth & Tobin, 2007). I assume that hybrid forms of subcultures are continuously created within main culture, giving rise to a vast number of identity projects. Such a notion then makes possible the study of the many different funds of knowledge and worlds the youth draw from and that constitute their participation and positioning in science over time.

CHAPTER 2

CONCLUSION: WHICH SCIENCE? WHAT LEARNING?
WHAT SCIENCE LITERACY?

Now that I have laid out the theoretical framework that guides the study of meaning making of science, I add a word about science and the ways I conceptualize science learning in this book. As already alluded to, learning to talk science is an essential component of science literacy. If we take serious the fact that science has its own discourse, children and youth have to appropriate that genre through learning opportunities in science in school and beyond. They have to appropriate the semantics of science discourse. They also need to learn to use language to mean science. Such may entail the distinguishing yet also integrating of everyday and scientific talk in ways that make it empowering for them and in turn, may facilitate the development of a rich toolkit of ways of talking and thinking science (Mortimer & Scott, 2003). They have to appropriate the story of science and its many genres, the school science genre being simply one among many others.

Engagement in and with science will help them construct new levels of understanding of the natural world and how it works. Simultaneously, they have to become apprenticed into the ways scientific evidence and explanations are generated and evaluated, which, in turn, will lead to an understanding of how scientific knowledge is constructed (i.e., nature of science). Together, these dimensions of science are essentially constitutive of the children's and youths' figured worlds of science (National Research Council, 2007). Such figured worlds then become the context for positioning work in that the youth have to position themselves in relation to the meanings of science and science practices that are known to them. Yet, they also have to learn about the ways science can be put to use and turned into action. Hence, science literacy entails knowledge of scientific content and method, but also an understanding of the impact of science on society and ones personal life, understanding its limits and possibilities for responsible social action.

We know little about diverse youths' engagement in science outside of school, the form such engagement takes and its impact on science literacy development and identity as a potential insider to science. We need to know more about why, how, and for whom out-of-school settings make a difference. Science in the Making at the Margin offers some answers through an in-depth and theoretically well-grounded multisited ethnography of three very different out-of-school settings: an afterschool program for girls only, a youth garden program, and a Math and Science Upward Bound Program. Science in the making at the margin: A multisited ethnography of learning and becoming in an afterschool program, a garden, and a math and science upward bound program. Rotterdam, Netherlands: Sense Publishers.Google Scholar. Rogoff, B. (2003). The cultural nature of human development. New York, NY: Oxford University Press.Google Scholar. Copyright information.