Science Education from People for People

Taking a Stand(point)

Edited by

Wolff-Michael Roth

Science Education from People for People

Contributing to the social justice agenda of redefining what science is and what it means in the everyday lives of people, this book

- introduces science educators to various dimensions of viewing science and scientific literacy from the standpoint of the learner, engaged with real everyday concerns within or outside school;
- develops a new form of scholarship based on the dialogic nature of science as process and product; and
- achieves these two objectives in a readable but scholarly way.

The authors want science education to be *for* people rather than strictly *about* how knowledge gets into their heads. Opposing the tendency to teach and do research as if science, science education, and scientific literacy could be imposed from the outside, they discuss applications of epistemologies not often recognized in science education, and offer an opposite position to the rhetoric of "No Child Left Behind" and its top-down approach to mandating what students need to know. Taking up the challenges of this orientation, science educators can begin to make inroads into the currently widespread irrelevance of science in the everyday lives of people.

Designed as a forum in which leading scholars present and interact about issues arising from the concept of scholarship from people for people, utmost attention has been given to making this book readable by the people from whose lives the topics of the chapters emerge, all the while retaining academic integrity and high-level scholarship.

Wolff-Michael Roth is Lansdowne Professor of Applied Cognitive Science at the University of Victoria, Canada.

Science Education from People for People

Taking a Stand(point)

Edited by Wolff-Michael Roth
University of Victoria

Routledge
Taylor & Francis Group
NEW YORK AND LONDON

First published 2009
by Routledge
270 Madison Ave, New York, NY 10016

Simultaneously published in the UK
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

Routledge is an imprint of the Taylor & Francis Group, an informa business

This edition published in the Taylor & Francis e-Library, 2009.

To purchase your own copy of this or any of Taylor & Francis or Routledge's collection of thousands of eBooks please go to www.eBookstore.tandf.co.uk.

Library of Congress Cataloging in Publication Data
Science education from people for people : taking a stand (point)/
edited by Wolff-Michael Roth.
p. cm.
Includes index.
1. Science–Study and teaching. 2. Science–Study and teaching–Social aspects.
3. Cultural pluralism. 4. Multicultural education. I. Roth, Wolff-Michael, 1953–
Q181.S36885 2009
507.1–dc22 2009003892

ISBN 0-203-87844-2 Master e-book ISBN

ISBN10: 0–415–99554–X (hbk)
ISBN10: 0–415–99555–8 (pbk)
ISBN10: 0–203–87844–2 (ebk)

ISBN13: 978–0–415–99554–2 (hbk)
ISBN13: 978–0–415–99555–9 (pbk)
ISBN13: 978–0–203–87844–6 (ebk)

Contents

Illustrations

Table

Figures

Contributors

Angela Calabrese Barton is Associate Professor of Science Education at Michigan State University. Her research in urban science education has focused on high poverty urban middle school youths' scientific literacies in and out of school, and on the preparation of teachers to teach science in high poverty urban communities.

Carol B. Brandt is Assistant Professor of Social Foundations at Virginia Polytechnic Institute and State University, Blacksburg. Her research and teaching examines the interplay among language, local knowledge, and science in contexts beyond the classroom (farm fields, kitchens, molecular biology laboratories, science museums, and parks).

Katherine Richardson Bruna is Assistant Professor of Multicultural and International Curriculum Studies at Iowa State University. A former bilingual educator and evaluator of educational policy and practice related to bilingual students in California, she is interested in issues related to culture, language, identity, and equity in schooling.

Christopher Emdin is Associate Professor of Science Education at Teachers College, Columbia University. He conducts research on issues of race, class, and diversity in urban science and mathematics classrooms. His most recent work explores new theoretical approaches to research in urban science education and student/teacher identity formation around science.

SungWon Hwang is Assistant Professor of Science Education at the National Institute of Education, Singapore. Prior to that she was postdoctoral fellow at the University of Victoria, where she conducted interdisciplinary research projects that articulate dialectic frameworks of learning and identity in the context of science and technological work.

Hannah Lewis, MS, is Assistant Scientist in Sociology and Sustainable Agriculture at Iowa State University. She coordinates bilingual programming to develop small-farm entrepreneurship among immigrants in diversified community-based food systems.

Eileen Carlton Parsons is Assistant Professor of Science Education at the University of North Carolina–Chapel Hill. She conducts research on the teaching and learning of science in the early and middle grades with respect to context, culture, and race.

Wolff-Michael Roth is Lansdowne Professor of Applied Cognitive Science at the University of Victoria. He conducts research on learning science and mathematics across the lifespan, from kindergarten to professional praxis (including science laboratories, fish hatcheries) from multiple theoretical perspectives (phenomenology, sociology, cultural studies, cognitive science) and for multiple communities of practice, including science studies, sociology, linguistics (pragmatics), learning sciences, and education.

Karen L. Tonso is Associate Professor of Social Foundations at Wayne State University (Detroit), studies engineering education by melding fifteen years in engineering with degrees in mathematics education, and anthropology of education. Her research examines relations of power, related to gender, race/ethnicity, social class, or other forms of life.

Preface

This book has three major objectives: (a) to introduce science educators to the various dimensions of viewing science and scientific literacy from the standpoint of real people; (b) to develop a new form of scholarship that is based on the dialogic nature of science as process and product for real, everyday people; and (c) to achieve the two previous objectives in a readable but scholarly way. In the same way as the sociologist Dorothy E. Smith, who takes a women's standpoint to her research, the authors of this volume take a standpoint that begins in the actualities of people's lives, their own or those of others with whom they are working closely. The results of these investigations are intended to be useful to those very people, not via a detour through academic discourse, that is showered upon and re-introduced to the people's lives by means of an "application" or "implication," but by means of a discourse that never leaves the lives of real people. As a result, the authors arrive at framing science and scientific literacy, and therefore also science education, in terms of everyday people, who become the sites of consciousness, mind, participative thinking, subjectivity, agency, identity, and so forth as a result of their doings. All contributors have experience in "writing from the margins"—to make the marginal position central in their perspective on science education. They are therefore well-positioned to write a science education *from* the people designed to be *for* the people rather than conforming to some *external* standard that pays lip service to taking into account the lives and experiences of the learner.

From the beginning, I planned this book as both very readable and very articulate about all matters of identity concerning science, science education, and science learning. I wanted a book that is grounded in the everyday experiences of different people in different parts of the continent and from different cultural backgrounds. During its conception, I was thinking about a book that is not simply a collection of a number of chapters that look more like journal articles with little connection between them. My vision was more like a forum, in which leading scholars present and interact about issues arising from the concept of scholarship from people for people.

To achieve this goal—and consistent with the proposed subtitle of this book—the authors, especially in the two *metalogue* sections, actively think through and propose alternative approaches to science and science education

for those people with educational agendas: teachers, parents, informal educators, non-governmental organizations, and others. This, then, is a third mode of subjectivity and activity, for the authors engage in making available resources and giving directions for *changing* their own and others' lifeworld rather than simply seeking to understand it (as in traditional quantitative and qualitative research).

This book is designed to be useful not only to a small group of initiates, people with the great level of expertise of the contributors, not only to a restricted wider scholarly audience, not only to graduate students (who are novices in the field of educational research), not only to colleagues not specializing in questions of research methods and methodology, and to academically trained policy makers including those who work in funding agencies. Rather, the book is intended for an intelligent and informed readership generally. All contributors' utmost attention has been given to producing their individual chapters and the book as a whole to be readable *by the people in whose lives the topics of our chapters emerge*, all the while retaining academic integrity and high-level scholarship.

Ways in which the authors achieve greater readability on the part of a broader audience is by (a) a reduced number of references in the text—additional references should be requested directly from the authors; and (b) the use of a language that non-specialists recognize as their own and a build-up (explication) of those important concepts that the chapter texts intend to convey—again, the text was held at a more general level and if needed, more specialist terminology, technical vocabulary, and explication are placed in footnotes.

Wolff-Michael Roth
Victoria, British Columbia
August 2008

1 Taking a Stand(point)

Introduction to a Science (Education) from People for People

Wolff-Michael Roth

The past 50 years have seen tremendous activity in science education, both in terms of the development of curricula and in terms of the research conducted on how people (mostly school students) know and learn science. Yet despite the tremendous amount of work done, many of the problems that had occasioned interest in the field after the Sputnik shock continue to persist. Thus, more than ever, many students do not see science as relevant to their lives and opt not to enroll in science courses at the secondary and post-secondary levels. More than ever, students do not opt for careers in science and scientists, reflecting on this issue in their flagship journal *Science*, wonder about ways in which they can increase the "throughput" in their science "pipelines." A concern for science education that is to serve and educate *all* members of society, however, cannot be the same as the one for throughput and pipelines. Whereas scientists' concerns are legitimate to the extent that we need scientists and engineers to produce knowledge that allows humans to control their environment and therefore to guarantee the survival of the species, science education *for all* has to be different in nature (Roth & Barton, 2004) because it has to address itself to the very different needs that distinguish the general public from those specific individuals whose needs are met when they pick up careers in science.

In this book, the authors as a collective therefore are not concerned with *throughput* or *filling the pipeline*. Rather, collectively they take the position that a key problem of past efforts is this: educators, psychologists, and natural scientists defined the nature of science, science education, and scientific literacy in terms of the products of laboratory science. The definitions of science have always been in terms of science content from a scientific perspective and in terms of disembodied forms of knowing. The definitions had little or anything to say about the tremendous experiences and competence everyday people (including students) have especially when they are uninstructed in science; and they had little to say about how science and science education could assist everyday, ordinary, and just plain folk in and with the problematic situations that they face in their ongoing lives. There are many such problems, as shown for example in the issues of (Zuni) gardening, having children, or facing (chronic) illness that feature in some of the chapters of this book. Yet these problems rarely if ever demand the kinds of knowledge that students are to

acquire in their science classes. Those who cope with illness do not need to know the Krebs cycle or Newton's third law; nor do Zuni gardeners need to know this form of science, as their own ways of gardening corn already is so much more adapted than the scientifically informed ways of industrial farmers. In the chapters of this book, therefore, there is little about how to cram—by transfer or construction—atoms, molecules, Krebs cycle, and Newton's third law into the heads of children. And these problems always are bound up with human beings, lived experiences, emotions, worries, effect–affect transactions, and so forth.

One of the questions some science educators concerned with science education and social justice ask is how to make the sciences more relevant to students specifically, and all members of society more generally. But how do we have to think, and think about science, so that it becomes more relevant? Certainly not in the same ways that have turned students away from the sciences for the past five decades since Sputnik was launched. With a re-orientation of science and scientific literacy in and through problematic issues in the lives of people, science educators might actually begin to make inroads into the currently intractable problem of the irrelevance of science in the everyday lives of students specifically and all everyday folks more generally. Science would be relevant in and to these lives if the people themselves recognized it as a resource for action and therefore as something that *expands their room to maneuver* and power to act—i.e., to their agency. This concern for science as a useful resource in and for the lives of everyday people is at the heart of this book. That is, science education in the way the contributors approach it here is centrally about social justice rather than the stuffing of science content into the heads of children, students, and everyday folks. But the sciences have to be more. In a democratic society, the sciences have to be open to critique, open to be contested, unless they want to be of the same status as religions that one has to take on faith.

This tension for science educators arises from the fact that they understand their task as one of teaching canonical science. A quick look at the news shows, however, that science is not just a resource in everyday life but also a contested terrain. This is immediately evident when we follow the debate about global warming, where each side finds scientists to support their ontological stance according to which global warming exists (as the former vice president A. Gore suggests in his documentary *An Inconvenient Truth*) or does not exist (as G. W. Bush upheld for a long period of time). It is clear that the science itself is becoming the terrain that is contested in a debate (or "battle") where science also is rallied in support of the various and divergent arguments. Allowing students specifically, and all people more generally, to draw on their knowledges as a resource to contest other forms of knowledge in decision-making processes leads to further tensions because of the incommensurability of the knowledgeabilities involved. Thus, scientists, policy makers, politicians, and everyday folk find themselves struggling with "integrating" forms of knowledge that cannot be integrated because they cannot be reduced to one another (e.g., Roth, 2008b).

Science as Resource and Contested Terrrain

The purpose of this book is to oppose the general tendency of doing science education (teaching, research) as if science, science education, and scientific literacy could be imposed from the outside, and as if the pertinent forms of knowing and learning were independent of the human orientation toward expansion of their room to maneuver. That is, the contributors take the position that adult, adolescent, and child learners will find science, scientific literacy, and science education relevant once they see and understand how their own possibilities of acting and being in the world expand. Such expansion comes with a positive (emotional) valence, which is therefore an important mediating aspect of becoming and engaging as a (science) learner. Therefore, in this book the contributors aim at constructing perspectives on science, scientific literacy, and science education grounded *in the lives of real people* and that are oriented toward *being for real people* (rather than disembodied minds). Our concerns thereby intersect with those of Dorothy E. Smith (2005), who, in writing *Institutional Ethnography*, produced a sociology *for* people. Collectively, the authors in this volume want science education to be *for* people rather than *about* how knowledge gets into the heads of people—be it by means of construction, transfer, or internalization.

One proposal in the past has been that science itself has to become a contested terrain and resource (Roth & Barton, 2004). Taking such an approach no longer allows science educators to think about the ways in which we can fit students specifically, and the general public more generally, to science as it is practiced in laboratories and in scientific journals. This is a form of science that, despite its origin in the everyday pursuit, languages, and practices of people, has become a form of practice that elevates and imposes itself as something special. Scientists have become the new high priests in a secular society. Whatever they have evolved as practice is taken and presented as something like a gold standard against which all other practices are evaluated—the discourses of students *mis*conceptions, *alternative* frameworks, or *naïve* conceptions constitute ample proof for the deficit discourse science educators employ with respect to everyday knowing. For scholars in the cultural studies, of course, this is but another culturally specific standpoint on knowledge and on knowledge production and evolution. It does not have to be that way, as the events surrounding the AIDS community have shown, and how AIDS activists have been able to bring about a change in the methods of testing new drugs (e.g., Epstein, 1995).

The analysis of AIDS research has become an important testing ground for the social sciences as AIDS activism exerted a politics of identity organized by constituencies around specific illnesses and diseases such as breast cancer, chronic fatigue, and environmental illness. The relations between AIDS activists and scientists in particular showed how science itself can become both a resource (e.g., in the development of new drugs) and a contested ground (e.g., as the standard ways of doing science come to be scrutinized, questioned, and changed). Here, the AIDS activists worked from a particular position, that of

people affected by the disease, and from the associated standpoint, communicated their point of view with such vigor that they were able to change how science is done and therefore what science is.

The standard method for testing the effectiveness of new drugs has been the double-blind experiment, randomization of participants to treatment and control, and working with particular populations. For example, AIDS trials employed samples consisting largely of middle-class white men. AIDS activists were able to argue that subject populations should be extended to injection drug users and hemophiliacs, women, minorities, and differing sexualities. They simultaneously pushed for (a) fair access to experimental drugs rather than random assignment and (b) generalizability. However, treatment activists have been able to engage scientists over the processes of drug testing and in the process have become legitimate players. Their legitimacy can be gauged from the fact that AIDS treatment activists have become, following a long struggle, full members of various committees of the U.S. National Institutes of Health that oversee drug development. They have also become participants in the advisory committee meetings of the U.S. Food and Drug Administration, where any new drug is considered for approval prior to being released.

The AIDS case is but one of a number of forms of activism that has had mediating influences on science and how it operates—i.e., its methods—and therefore on the very definition of science. Thus, organizations of people with a variety of diseases and illnesses have been able to assert their needs and mediate *what* science is done and *how* it is done: Those struck with illness *do have* power, as medical sociologists have shown (Rabeharisoa & Callon, 1999). Environmental activists have inserted themselves into the public debate and policy making concerning the testing and use of genetically modified organisms. And individuals from First Nations and just plain folks (e.g., fishermen in Newfoundland) around the world have begun to work with scientists and thereby brought about changes in the ways in which relevant systems are modeled, tested, and theorized. Thus, for example, the "Back to the Future" (e.g., Pauly, Pitcher, & Preikshot, 1998) approach uses complex computer-aided tools to combine vastly different forms of knowledge, such as the ones scientists produce in their laboratories and the local knowledge of Aboriginals and residents.

In each chapter that follows, the respective author/s take up the challenge of writing an approach to science, scientific literacy, and science education with a problem *relevant to one or more real persons* and to develop theory and a description of their approach out of this problem. This therefore becomes a science education *from the standpoint* of the knower/learner, engaged with real everyday concerns either within or outside school. That is, rather than developing a theoretical framework that will be imposed on some data materials, the authors begin with a problem in the lives of people (children, adolescents, adults) and then engage in a form of institutional ethnography, which begins with everyday experience as the grounds from which discoveries can be made. The resulting (and necessary) standpoint will be that of children, women, persons of

color, Aboriginals, expecting mothers, or a person afflicted with chronic but undiagnosed illness. The authors thereby come to think and theorize science education from the place of those who learn and from the place of the people who might become interested because the payoffs from engaging with science in one or another form include an increase in their agential room to maneuver.

In accordance with Dorothy E. Smith's work, the important dimension of doing research from a particular "standpoint" is that it does not subordinate the knowing subject to forms of knowledge that have been objectified and codified into science textbooks, that is, to the societal-hierarchical forces in a political economy. The present authors allow us to think ethnographically (sociologically, anthropologically) from the place of real people (including themselves) struggling with one or another facet of daily life (including school life). Yet, as those in movements of previously (and present-day) marginalized groups know, there are experiences that discourse does not articulate, and institutional ethnography is one of the tools that can uncover and make thematic these experiences. This also requires social scientists to go beyond what is apparent to real people: like the concepts (ideologies) and artifacts that we have come to use, there are things in our lives that have a determinate effect on what we do. These concepts and artifacts have an insidious effect in the sense that they may go against the interests of real people, instead serving those in power and the ruling relations. For example, in one town of British Columbia about 15% of the students were on Ritalin because they were said to have ADHD (attention deficit hyperactive disorder). Surely, there is not 15% of a population afflicted; and there are other ways to deal with attention than drugging children. Here concept of ADHD appears to be used to subjugate and drug children, who are calmed to the point that they are submissive, and it has little to do with the real lives of these children. But parents are made to buy into the use of Ritalin simply because it is said to deal effectively with ADHD. This formula (name) therefore serves as a (discursive) tool to make parents and children buy into and therefore produce and reproduce a practice that ultimately only serves the pharmaceutical industry.

The chapter contributions in and to this book strive to bring together two modes of subjectivity and activity that ordinarily have been kept separate: our personal lives as mothers, ill persons, student in a science class, Aboriginals in science, environmentalists, etc. that we share with others and our professional lives as academics. In these latter lives, we have all too often tended to objectify knowledge (discourse), on the one hand, and those who know and learn, on the other hand. Consciousness thereby came to be stripped of local particularities, auto/biographies, contingencies, needs, and emotions of people to whom some form of science and scientific literacy could become a resource. (Here, we do not pre-specify the nature of science and scientific literacy but rather leave it open to rearticulate what their nature is as an outcome or implication of the work reported.) Especially in the two *metalogue* chapters, the authors actively think through and propose alternative approaches to science and science education *for* the people.

Content and Structure of this Book

The book consists of 12 chapters, including two discussion forums ("metalogues") and is grouped into two parts, "Culturing Knowledges" and "Othering the Self, Selfing the Other." In the following two subsections, I briefly describe, contextualize, and relate the contents of the chapters in the two parts.

Part I: Culturing Knowledges

The title of the first part of this book evokes the inseparable connection all knowledge has to culture with the *double entendre* that knowledges also have to be cultured (nurtured). Etymologically, the term "culture" derives from the participle of the Latin *colĕre*, to attend to, respect. The word then made it from the term *cultura*, cultivation, tending, and worship through the French culture (*couture*) into English. In its present-day use, besides being a theoretical term in cultural studies, anthropology, and sociology, the term also refers to the action of cultivating soil, tillage, rearing plants and animals. In an interesting article about culture and identity, the etymology and these other senses of the word are brought into play to argue against culture as something pure:

> "Cultures," or whatever we call by this name, do not add up. They encounter one another, mix with one another, alter one another, reconfigure one another. They cultivate one another, clear one another's ground, irrigate or drain one another, work one another or mutually graft themselves onto the other. (Nancy, 1993, p. 13, my translation)

As a result, there is nothing like *a* culture, because every entity thus denoted is itself multicultural and the result of a continual *mêlée, that is, of a* process "of affronting, confronting, transforming, detouring, developing, recomposing, combining, and doing bricolage" (p. 13). With culture, all of its elements are subject to the same processes, so that we cannot think of language or identity as self-same concepts denoting self-same phenomena. Identity, language, knowledge, and so on are heterogeneous *processes*, continuously making and remaking themselves, never quite themselves and always already other than themselves at the very instant that they realize one of their possibilities—in actualized identity, realized utterance or written sentence, concretely articulated and enacted knowledge. Historical developments of culture and language cannot be understood unless every (speech) act already is considered a change in and of what has been available up to the moment of its beginning (Bakhtin/Vološinov, 1973).

All chapters in this first part focus on the experience of science and on scientific knowledge at and across the border of different inherently heterogeneous cultures—African Americans (people of color) in a largely white society (Parsons, Emdin), Zuni Indians and Latino/as in the US, Asians (Korea, Japan) in Canada (Hwang, her participant). The chapters show that knowledges are not impersonal but fundamentally situated in and mediated by culture and

language, themselves not unities or unicities but multiplexes and pluralities. Learning science therefore is more than appropriating a new code, and requires a reconfiguration of the Self or a reconfiguration of science. In any event, it requires a continuous hybridization of cultures and cultural knowledges.

In "Revisiting and Reconsidering Authenticity in Science Education: Theory and the Lived Experiences of Two African American Females," Eileen Carlton Parsons, an African American scholar, addresses the perceived universality of Western science and the way the promulgation of this universality in the practices of science education and scientific literacy serves to exclude many voices, ways of knowing, and ways of being that could potentially enhance science and its meaningfulness. In this chapter, Eileen literally places two narratives side by side. On the one side, there are the stories of two African American women brought up in two historically distinctive eras—an 81-year-old from the rural poor with an elementary education and a 30-year-old from the rural middle class who holds a PhD. On the other side, Eileen articulates a framework synthesized from two conceptual models in psychology, Western science as particularistic rather than universal. The juxtaposition of the two forms of text allows her to articulate and examine insights pertaining to life-based authenticity as it relates to Western science, science education, and scientific literacy.

In her chapter "Faith in a Seed: Social Memory, Local Knowledge, and Scientific Practice," Carol B. Brandt, who grew up in an agricultural community where growing one's own food was second nature in everyday life, is concerned with sites for learning science outside of schools that are framed and shaped by social, economic, and political discourses. Gardening was woven into the "common sense" of her community and, along with other youth, she attended 4-H meetings[1] organized by the county agricultural extension agents, and began to record "scientific data" on yields and to experiment with new varieties. Agriculture in this German-American community was infused with Christian values and a staunch faith in Eurocentric science as a result of the Progressive Era that revolutionized Midwestern farming in the 1920s. Attached to this local knowledge and informal science were discursive constructions of time and space that also ordered community practices. None of her experiences, however, prepared Carol for gardening in west central New Mexico. On the high desert plateau, the arid environment is marginal for growing conventional crops, and yet Zuni is the home to one of the oldest Indigenous agricultural traditions in the United States. When Carol began working with Zuni farmers and gardeners her notions of "common sense" in agricultural practices shifted while she examined gardening as the relationship among local knowledge, economics, and the political history of Eurocentric science in this Indigenous community. In her chapter, Carol chronicles how she grasped the role of social memory in maintaining local knowledge in an agricultural repertoire despite dramatic economic and social change. In learning how to garden in a Zuni way, she came to understand how Eurocentric science is part of a larger custodial discourse between the federal government and Indigenous people. Drawing

from interviews with 50 gardeners and farmers at Zuni, she describes ways in which local knowledge is parsed and dispersed in the community, and how local conceptions of space-time is often at odds with Eurocentric science.

The mediations of learning that come with migrating from one country and culture to another, a prevalent experience in an increasingly globalized world, is the topic of chapter 4 entitled "Language and Experience of Self in Science and Transnational Migration." The two authors and their research participant have migrated to Canada, two from Asian countries (SungWon Hwang [Korea], Miko [Japan]) and one from Europe (Wolff-Michael Roth [Germany]), and all three have begun their lives in a culture other than the Anglo-Saxon Canadian that historically defined the area in which they now live—though in many homes today English is not the language of choice (in Vancouver, less than 45% of families speak English at home). Moving from one culture to another is not a problem from rationalist perspectives, because it simply involves changing from one system of codes (language, culture) into another. From such a perspective, all one has to learn is how to translate between the two forms of code. All three individuals in this chapter have experienced how transnational migrations both within Western culture and from Eastern to Western cultures are associated with a substantial loss of bearings that normally allow a person to make sense. This transnational migration brings about a shift in identity that is also experienced in learning science, where students are introduced to the new languages of the subject matter by means of everyday language that is of the dominant culture of the school or university. Locating this chapter in their own experience of moving between nations and cultures, the authors articulate issues that the shift to speaking a language other than their mothers' tongues brings forth to the experience of self and how it mediates learning in and of science.

Another form of cultural relation is that between hip hop and standard culture, itself already a hybrid arising from the continual bricolage that occurs at the interstices between the middle-class values underlying schooling (Eckert, 1989) and the different cultural roots that characterize students' lives outside schools. Although we can think of hip hop as a culture within culture, we ought not to essentialize the phenomenon but rather understand it as multicultural at its heart. In chapter 5, "Reality Pedagogy: Hip Hop Culture and the Urban Science Classroom," Christopher Emdin shows how hip hop serves students of color in urban areas as an escape from the struggles of their everyday lives. Lyrics to rap songs tell tales of both the physical realities of life in the inner city and the emotional frustration that comes with being ostracized from and silenced in mainstream culture. There is a mutually constitutive relationship between rap and the inner city that those that are involved in hip hop deeply understand. The streets speak to the music and the music reports what it hears from the streets. Those individuals not actively involved in hip hop often believe that the hip hop generation is the underbelly of American culture. These individuals fail to realize that hip hop is a product of a lack of voice in schools and the political arena. In his research, Chris finds urban students engaged in

hip hop culture to possess many attributes that support success in science that are not fully explored in urban classrooms. He constructs for us a path to uncover students' experiences that are integral to the teaching and learning of science. He achieves this goal by engaging in dialogues with students who are both participants in hip hop culture and students of science in secondary schools. Through these dialogues, Chris presents a reality-based urban science pedagogy nested in students' experiences and hip hop culture.

Diaspora is an old phenomenon and, more recently, has become an important theoretical concept in cultural studies generally and in science education specifically (Roth, 2008a). It allows us to understand the experience of migrants between different parts of the world. In the US, there is a new phenomenon whereby rural communities are rapidly becoming unofficial sister cities to rural communities in Mexico. Scholars denote this phenomenon by the term "New Latino Diaspora" (Wortham, Murillo, & Hamann, 2002). Small-scale Mexican farmers and their families, displaced due to North American Free Trade Agreement-induced privatization of once-communal farmland and a flood of cheap American corn, are moving north in record numbers to secure employment in the de-skilled and de-unionized meatpacking industry of the American Midwest. This diasporic movement from the south to the north involving nearly entire communities constitutes an historic transformation in the labor markets and living and learning modalities of both sending (Mexican) and receiving (Iowan) rural communities. The struggle of small independent farmers against the industrialization and centralization of agriculture is a unifying theme on both sides of the border. Yet the heated rhetoric over illegal immigration and the "browning" of America's heartland drowns out this common concern.

Drawing from a multi-site ethnography of two Mexican and Iowan sister cities, Katherine Richardson Bruno and Hannah Lewis contrast in their chapter "Sister City, Sister Science: Science Education for Sustainable Living and Learning in the New Borderlands" the coordination of "work knowledges." This coordination cobbles together and transforms the knowledge Mexican families bring to their participation in the U.S. food production systems with the canonical content knowledge of school science. Challenging the long-standing subjugation of these everyday work knowledges in mainstream science, Katherine and Hannah argue instead that such knowledges are critical to reconceptualizing science education in the age of globalization and global migration. The current privileging of U.S. economic advancement through technological innovation, offered as a rationale for efforts to improve science education for non-dominant students in the reforms of *Science For All*, does not speak, for example, to the desire of immigrant students and their families to return to the farming lives they left behind in Mexico. Nor does it speak to them should they remain in the US and move away from the exploitative labor of packing plant work to be able to work where their agrarian backgrounds support what they do. Taking the goal and framework of *sustainable rural livelihoods* as its point of departure, the chapter concludes by re-framing science education

from a globalized and diasporic standpoint and outlines the need for and nature of a proposed border science curriculum for transnational living and learning. Such a curriculum, it is suggested, could be a source of social dreaming and healing for all students and families in the sister cities of the new borderlands.

In chapter 7, the authors of the preceding chapters discuss implications that spring forth from their work organized around four questions that the editor asked them to respond to. In this *metalogue*—according to Gregory Bateson (1972) a conversation that takes learning to a new level by learning about learning—the authors discuss issues such as (a) the divide between academics and everyday folk, (b) teaching science in ways that respect everyday forms of knowing, (c) the possibilities that come with everyday knowing and place-based science education, and (d) the relation of teaching "authentic science" and everyday knowing.

Part II: Othering the Self, Selfing the Other

Despite the traditional rhetoric of making science relevant to students, their lives and life experiences are generally excluded in the quest of inculcating (allowing self-construction of) the "right" scientific knowledge as specified in national standards. Even the staunchest constructivists, claiming that knowledge is personally constructed on the ground of existing knowledge and understanding, nevertheless want their students to arrive at the "right," "canonical" form of knowledge. In the form of conceptual change theory, constructivist educators actually aim at rupturing students' existing understandings, attempting to make them "restructure" their mind from misconception or alternative conception to the correct, scientific conception. The ways of the students' homes and everyday lives thereby come to be devalued and students are asked to abandon forms of discourse that continue to have currency in their lives outside the science classroom. Not surprisingly, then, we find that only a small percentage of students like science and pursue science-related careers after graduating from high school.

All three chapters in this section and the metalogue that follows allow us to see the active interplay that exists between Self and Other (the generalized other), each of which presupposes the respective other. In constructivist terms, the Other is a figment of the Self, the result of a construction tested for its viability in exchange with whatever the term denotes. The Other thereby is made in the image of the Self, which is the source of the construction and which thinks the other in its own image. This framing of the self–other relation in educational theorizing at the end of the 20th century is surprising given that, already at the beginning of the century, the philosopher Edmund Husserl showed that a self could never construct anything like an other. Thus, Husserl realized that "I" cannot identify the behavior of someone else as angry or wrathful without first adopting the viewpoint of another on my own affects (Franck, 1981). It is under this sole condition that the "I" can recognize another's bodily manifestation as indicating anger or wrath. It is therefore not

the Self that serves us as a model for the Other, but rather the Other that serves as a model for the Self: anything we can express about language—which we appropriated from the other, for the purposes of communicating with the other, in a process of which language returns to the other—inherently *is* other than the Self.

At the same time, an agential conception of the Self introduces the possibility to produce novel expressions, which, though already circumscribed within the currently possible language, nevertheless is realized in a singular way and therefore produces resources that become available to the other, who thereby comes to shape himself or herself in the image of the Self. Both Self and Other, therefore, are impure, metis, always and already utter singularity and absolute general at the same time.

The chapters in this section show that science, scientific knowledge, and scientific literacy—if these terms are to be relevant to everyday people coping in their everyday lives—can and ought to be rethought from the perspective of the individual. The authors in this part take their own personal experiences—Angela Calabrese Barton as expecting mother, myself as a chronically ill individual, and Karen Tonso as a woman in engineering—as a starting point for a critical interrogation of science and scientific knowledge for developing ways of thinking about science education.

An integral aspect of many families generally and of women specifically are the times of pregnancy and the early years in a child's lives. Families are struggling with the situation and they strive to know more about how to deal and live with the soon-to-come or recently arrived. The needs to become knowledgeable about health, illness, and so on are salient, and the question we ought to pose regards how we can rethink science to be relevant in such situations. This is the topic of Angela Calabrese Barton's chapter "Mothering and Science Literacy: Challenging Truth-Making and Authority through Counterstory." When she became pregnant with her first child, Angela was told by many people: "You need to read *What to expect when you are expecting*." So, as a dutiful new mother she went out and purchased the book, and about five others describing the ins and outs of pregnancy and babies. After all, she felt like a science educator and knowledge of how the body works is interesting to her, especially when it is her own body! But Angela quickly became frustrated because the tone of most of these books not only felt paternalistic, but also essentializing, as if all pregnant bodies worked the exact same way. Angela knew she should feel some morning sickness and should sleep with crackers next to her bed to eat when she woke up to alleviate my symptoms. She should not exercise rigorously and should stay away from non-healthy foods like ice cream. She did understand the "science" behind these recommendations, but the essential claims did not fit her world. The thought of crackers made her stomach churn, and running an easy 4 miles made her feel well—as I know from having met her after a run while she was in her last month of pregnancy. So, she expanded her search for information, including joining an on-line community of other about-to-be mothers. A subset of them formed their own private forum

because, as they got to know each other better, they wanted a safer space to share their stories and experiences about their children and themselves. Since that time many of these mothers have met "in real life" though their friendships survive on-line.

The problems in the early life of her second baby emerged in this context of her early experiences. Whereas this community has served as multifaceted site in terms of the reasons why the women post there, as a mother who is interested in science learning and science literacy, Angela was struck at how this space has become a knowledge-generating community that lacks both the essentialist and paternalistic overtones of those books she purchased five years prior to that time. The knowledge of this community, which is distributed, personal, contextual and often contested, has not replaced the world of doctors or formal medicine, but has become one of the filters Angela uses to understand herself and her children's health. For example, beginning from birth, the head of her second child always tilted to the right. Her pediatrician did not think much of it because at the doctor's office her daughter never quite "performed" in a way that would demonstrate this tilt. But it nagged Angela and her partner. She took a few pictures and showed them to her on-line friends. Two immediate responses in particular suggested that this looked like *torticollis* (a Latin word that literally means "twisted neck"), and the writers suggested that Angela ought to pursue it before it caused head bone misalignment. As it turns out, each of these women has had a child with *torticollis*, but neither child was diagnosed on time and both subsequently required the corrective helmets to realign the head bones. Indeed, 5 minutes in a pediatric neurologist's office confirmed this diagnosis for Angela's daughter, and she is grateful to her on-line friends for their early intervention! Fortunately for her daughter, corrective physical therapy allowed the body to heal itself. In her chapter, Angela explores how this on-line community of mothers without medical degrees (and many without college degrees) has provided her with a collective wisdom that is personal, contextual and contested.

In chapter 9, I use my own experience of living with chronic illness to reflect on science and science education. Chronic illness has become salient in my life, as I have become increasingly aware in recent years that there are many people in my wife's or my own workplaces who live with chronic (sometimes terminal) illness. After two bicycle accidents in 2001, I found myself physically and cognitively impaired, without initially linking the accidents and my state. There followed years of testing for different kinds of possible illnesses, including amyotrophic lateral sclerosis (ALS or Lou Gehrig's disease). In all of this, I found myself at the mercy of a system that did not and perhaps could not help me, leaving it up to myself to live through a frequently debilitating condition that ultimately received a name: chronic fatigue syndrome/fibromyalgia. In chapter 9 entitled "Living with Chronic Illness: An Institutional Ethnigraphy of (Medical) Science and Scientific Literacy in Everyday Life," I use this experience and my search for a scientific understanding of what was happening to me and of the solutions I envisioned and enacted, which ultimately were associated with

a radical improvement of the condition. The experience and my understanding thereby constitute the ground for understanding and redefining science and scientific literacy in the everyday life of a person who not only is led to coping with the situation but also to evolve ways of mobilizing science and scientific research reports to provoke a return to wellness.

For 19 years, Karen L. Tonso was an engineer after having made it through a male-dominated training and into an equally male-dominated profession. After deciding to return to graduate school to become an educator, she found an opportunity to revisit her own training in the light of an ethnographic study in a public engineering school. In "A Stranger in a 'Real Land': Engineering Expertise on an Engineering Campus" (chapter 10), Karen revisits the question of what it might mean to become and be an expert. In the mid-1990s at Public Engineering School (PES) in the U.S. mid-continent, two forms of engineering expertise existed. One form aligned with an academic-science form of life associated with conventional, ABET[2]-accredited curricula in engineering education, the other embraced a comprehensive set of understandings and practices, in my experience and according to studies of engineering, better suited for work as "actual" engineers, student engineers' term for practicing engineers. The second form of expertise emerged from reform efforts, especially appending a design curriculum to conventional curriculum, where students worked in teams to complete projects for industry and government clients. With 15 years of industry engineering experience, it took her little time to recognize "real" engineering expertise when she saw it during student teamwork, but it has been quite another matter to convince engineering educators that *academic-science expertise*, privileged at PES (and other campuses) by campus traditions, routines for success and excellence, teaching practices (especially learning activities and grading), and other cultural norms will in fact be a "stranger" when students enter industry careers, or figuratively the "real" land. This chapter juxtaposes her perspectives as educational researcher and as former engineer to reflect on and trouble engineering expertise, and suggest why the one preferred at PES is arguably "strange" to a "real" engineer. Doris Lessing's observation about the elderly—"Your body changes, but you don't change at all. And, that, of course, causes great confusion"[3]—captures the nature of reform at PES.

In chapter 11, the three contributors to this section engage in a metalogue that covers emotions, knowledgeability, the relation of multiple knowledges as source for decision making, and the contradictions that science teachers and science educators face when they are to take into account the personal knowledges people evolve in the course of their lives, on the one hand, and the frequently incompatible scientific knowledges that are to be taught in the schools, on the other hand.

Throughout the book, it becomes evidence that taking into account peoples' lives means dealing with and *appreciating* differences, especially those that arise from the contrast and contradictions between science and everyday ways of knowing. I therefore end this book with an epilogue in which I reflect on

difference as such, that is, in and for itself, and how to appreciate difference when we think about and plan curriculum.

Notes

1 4-H is a youth organization in the USA, administered by the Cooperative State Research, Education, and Extension Service, which allows young people to develop citizenship, keadership, and life skills through programs based on experiential learning.
2 ABET stands for Accreditation Board for Engineering and Technology and is the recognized accreditor for colleague and university programs in applied science, computing, engineering, and technology.
3 http://www.worldofquotes.com/author/Doris-Lessing/1/index.html

References

Bakhtin, M. M./Vološinov, V. N. (1973). *Marxism and the philosophy of language*. Cambridge, MA: Harvard University Press.

Bateson, G. (1972). *Steps to an ecology of mind*. New York: Ballantine.

Eckert, P. (1989). *Jocks and burnouts: Social categories and identity in the high school*. New York: Teachers College Press.

Epstein, S. (1995). The construction of lay expertise: AIDS activism and the forging of credibility in the reform of clinical trials. *Science, Technology, & Human Values, 20*, 408–437.

Franck, D. (1981). *Chair et corps: Sur la phénoménologie de Husserl* (Flesh and body: On Husserl's phenomenology). Paris: Les éditions de Minuit.

Nancy, J.-L. (1993). L'éloge de la mêlée [Eulogy to the mêlée]. *Transeuropéennes, 1*, 8–18.

Pauly, D., Pitcher, T. J., & Preikshot, D. (1998). *Back to the future: Reconstructing the Strait of Georgia ecosystem*. Vancouver, Canada: University of British Columbia Press.

Rabeharisoa, V., & Callon, M. (1999). *Le pouvoir des malades: L'Association française contre les myopathies et la recherche* (The power of the ill: The French Association against Dystrophies and research). Paris: Les Presses de l'école des Mines.

Roth, W.-M. (2008a). Bricolage, métissage, hybridity, heterogeneity, diaspora: Concepts for thinking science education in the 21st century. *Cultural Studies of Science Education*, 3 891–916.

Roth, W.-M. (2008b). Constructing community health and safety. *Municipal Engineer, 161*, 83–92.

Roth, W.-M., & Barton, A. C. (2004). *Rethinking scientific literacy*. New York: Routledge.

Smith, D. E. (2005). *Institutional ethnography: A sociology for people*. Lanham, MD: AltaMira Press.

Wortham, S., Murillo, E. G., & Hamann, E. T. (Eds.). (2002). *Education in the new Latino diaspora: Policy and the politics of identity*. Westport, CT: Ablex.

References

1 Taking a Stand(point): Introduction to a Science (Education) from People for People

Bakhtin, M. M./Volos˘inov, V. N. (1973). Marxism and the philosophy of language. Cambridge, MA: Harvard University Press.

Bateson, G. (1972). Steps to an ecology of mind. New York: Ballantine.

Eckert, P. (1989). Jocks and burnouts: Social categories and identity in the high school. New York: Teachers College Press.

Epstein, S. (1995). The construction of lay expertise: AIDS activism and the forging of credibility in the reform of clinical trials. Science, Technology, & Human Values, 20, 408–437.

Franck, D. (1981). Chair et corps: Sur la phénoménologie de Husserl (Flesh and body: On Husserl's phenomenology). Paris: Les éditions de Minuit.

Nancy, J.-L. (1993). L'éloge de la mêlée [Eulogy to the mêlée]. Transeuropéennes, 1, 8–18.

Pauly, D., Pitcher, T. J., & Preikshot, D. (1998). Back to the future: Reconstructing the Strait of Georgia ecosystem. Vancouver, Canada: University of British Columbia Press.

Rabeharisoa, V., & Callon, M. (1999). Le pouvoir des malades: L'Association française contre les myopathies et la recherche (The power of the ill: The French Association against Dystrophies and research). Paris: Les Presses de l'école des Mines.

Roth, W.-M. (2008a). Bricolage, métissage, hybridity, heterogeneity, diaspora: Concepts for thinking science education in the 21st century. Cultural Studies of Science Education, 3 891–916.

Roth, W.-M. (2008b). Constructing community health and safety. Municipal Engineer, 161, 83–92.

Roth, W.-M., & Barton, A. C. (2004). Rethinking scientific literacy. New York: Routledge.

Smith, D. E. (2005). Institutional ethnography: A sociology for people. Lanham, MD: AltaMira Press.

Wortham, S., Murillo, E. G., & Hamann, E. T. (Eds.). (2002). Education in the new Latino diaspora: Policy and the politics of identity. Westport, CT: Ablex.

Introduction to Part I

3

4

5

6

7

8

9

1011

1

2

3111

4

5

6

7

8

9

20111

1

2

3

4

5

6

7

8

9

30111

1

2

3

4

35

6

7

8

9

40111

1

2

3

2 Revisiting and Reconsidering Authenticity in Science Education: Theory and the Lived Experiences of Two African American Females

Boykin, A. W. (1986). The triple quandary and the schooling of Afro-American children. In U. Neisser (Ed.), The school achievement of minority children (pp. 57–92). Hillsdale, NJ: Lawrence Erlbaum Associates.

Boykin, A. W. (1994). Harvesting talent and culture: African American children and educational reform. In R. J. Rossi (Ed.), Schools and students at risk: Context and framework for positive change (pp. 116–138). New York: Teachers College Press.

Bronfenbrenner, U. (1979). The ecology of human development: Experiments by nature and design. Cambridge, MA: Harvard University Press.

Buxton, C. (2006). Creating contextually authentic science in a “low-performing” urban elementary school. Journal of Research in Science Teaching, 43, 695–721.

Cole, M. (1996). Cultural psychology: A once and future discipline. Cambridge, MA: Harvard University Press.

Parsons, E. C. (2008). Positionality of African Americans and a theoretical accommodation of it: Re-thinking science education research. Science Education, 92, 1127–1144.

3 Faith in a Seed: Social Memory, Local Knowledge, and Scientific Practice

3

4

5

6

7

8

9

1011

1

2

3111

4

5

6

7

8

9

20111

1

2

3

4

5

6

7

8

9

30111

1

2

3

4

35

6

7

8

9

40111

1

2

3

4 Language and Experience of Self in Science and Transnational Migration

3

4

5

6

7

8

9

1011

1

2

3111

4

5

6

7

8

9

20111

1

2

3

4

5

6

7

8

9

30111

1

2

3

4

35

6

7

8

9

40111

1

2

3

5 Reality Pedagogy: Hip Hop Culture and the Urban Science Classroom

3

4

5

6

7

8

9

1011

1

2

3111

4

5

6

7

8

9

20111

1

2

3

4

5

6

7

8

9

30111

1

2

3

4

35

6

7

8

9

40111

1

2

3

6 Sister City, Sister Science: Science Education for Sustainable Living and Learning in the New Borderlands

Conner, C. D. (2005). A people's history of science: Miners, midwives, and "low mechanics." New York: Nation Books.

Fussell, B. (1992). The story of corn. New York: Alfred A. Knopf.

Kyle, W. C., Jr. (2001). Foreword: Toward a political philosophy of science education. In A. C. Barton, & M. D. Osborne (Eds.), Teaching science in diverse settings: Marginalized discourses and classroom practice (pp. xi-xvii). New York: Peter Lang.

Padilla, M. J. (2001). Life science. Upper Saddle River, NJ: Prentice Hall.

Pollan, M. (2006). The omnivore's dilemma: A natural history of four meals. New York: Penguin.

Richardson Bruna, K., & Vann, R. (2007). On pigs and packers: Radically contextualizing a practice of science with Mexican immigrant students. Cultural Studies of Science Education, 2, 19-59.

Shiva, V. (2000). Stolen harvest: The hijacking of the global food supply. Cambridge, MA: South End Press.

Sleeter, C. E. (2005). Un-standardizing curriculum: Multicultural teaching in the standards-based classroom. New York: Teachers College Press.

Smith, D. E. (2005). Institutional ethnography: A sociology for people. Lanham, MA: AltaMira Press.

Wallace, H. A., & Brown, W. L. (1988). Corn and its early fathers (rev. ed.). Ames: Iowa State University Press.

7 Cultural Encounters, Countering Enculturation: Metalogues about Cultures and School Science

3

4

5

6

7

8

9

1011

1

2

3111

4

5

6

7

8

9

20111

1

2

3

4

5

6

7

8

9

30111

1

2

3

4

35

6

7

8

9

40111

1

2

3

Introduction to Part II

3

4

5

6

7

8

9

1011

1

2

3111

4

5

6

7

8

9

20111

1

2

3

4

5

6

7

8

9

30111

1

2

3

4

35

6

7

8

9

40111

1

2

3

8 Mothering and Science Literacy: Challenging Truth-Making and Authority through Counterstory

3

4

5

6

7

8

9

1011

1

2

3111

4

5

6

7

8

9

20111

1

2

3

4

5

6

7

8

9

30111

1

2

3

4

35

6

7

8

9

40111

1

2

3

9 Living with Chronic Illness: An Institutional Ethnography of (Medical) Science and Scientific Literacy in Everyday Life

3

4

5

6

7

8

9

1011

1

2

3111

4

5

6

7

8

9

20111

1

2

3

4

5

6

7

8

9

30111

1

2

3

4

35

6

7

8

9

40111

1

2

3

10 A Stranger in a “Real” Land: Engineering Expertise on an Engineering Campus

3

4

5

6

7

8

9

1011

1

2

3111

4

5

6

7

8

9

20111

1

2

3

4

5

6

7

8

9

30111

1

2

3

4

35

6

7

8

9

40111

1

2

3

11 Diversity of Knowledges and Contradictions: A Metalogue

3

4

5

6

7

8

9

1011

1

2

3111

4

5

6

7

8

9

20111

1

2

3

4

5

6

7

8

9

30111

1

2

3

4

35

6

7

8

9

40111

1

2

3

12 Appreciating Difference in and for Itself: An Epilogue

3

4

5

6

7

8

9

1011

1

2

3111

4

5

6

7

8

9

20111

1

2

3

4

5

6

7

8

9

30111

1

2

3

4

35

6

7

8

9

40111

1

2

3