Cultural Studies of Science Education 12

Catherine Milne
Kenneth Tobin
Donna DeGennaro *Editors*

Sociocultural Studies and Implications for Science Education

The experiential and the virtual

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Cultural Studies of Science Education

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Contents

Introduction

The genesis of this book was a Cultural Studies of Science Education Forum organized by Kate Scantlebury and Sonya Martin at Drexel University in 2010. The theme of the forum was *Theoretical and Methodological Issues in Socio-Cultural Studies*, and reading through the chapters that make up this book I can only reflect on how appropriately the chapters address this theme. An intriguing aspect of this forum was that colleagues who were unable to attend in person could participate virtually through *SecondLife*® at the Drexel Virtual Consortium. Indeed, one of our authors, Carolyne Ali-Khan, did just that, and her chapter is a reflection, through a Shakespearean lens, on the nature of avatars and the world they inhabit. She explores how avatars are both us, that is, people in the real world, and not us, as the avatars with whom she interacted so clearly communicated to her: as fiction and nonfiction. Her chapter is complemented by Michael Meuller's autoethnography of his SecondLife experience in which he explores issues of identity and ethics in this virtual environment.

The chapters in this book address two major questions: what are some of the methodological and theoretical issues in sociocultural research in urban education and science education? What sort of questions do technological and virtual contexts raise for these types of research perspectives?

Kenneth Tobin provides a history of sociocultural research in science education through his experiences as a scholar and educator. He also introduces these main themes through his exploration of different forms of inquiry that he has used through his research life history applying what he describes as a multilogical approach to research. Tobin is one of the most influential sociocultural science education researchers, a scholar who recognized early in his research trajectory the need to apply sociocultural perspectives to science education research. In the search to hear the voices of students and teachers he began a broad range of initiatives that have been taken up by scholars including the role of authenticity and ethics in science education research, the use of cogenerative dialogues and coteaching in urban classrooms, and the role of emotions. In the process, he has created spaces for other

researchers to explore sociocultural issues and a number of scholars in this book have applied these tools to extend the sociocultural mission in science education research. Also, building on research on mindfulness and the role of emotions, Tobin explores the affordances of Jun Shin Jyutsu for exploring people's ways of acting and being in different contexts including dissertation defenses and research meetings. Tobin's chapter sets the context for a number of chapters that explore important questions associated with the conduct of research.

Gene Fellner argues that beyond dialectics researchers should be exploring multilectic approaches to research and analysis. As Kenneth Gergen (1994) noted, often, even in sociocultural research, it is easy for researchers to become blinkered and focus only on the issues of importance to their analysis, so the world becomes flattened and polarized around a single focus. However, Fellner argues that a multilectic approach, an approach that embraces multiplicity, challenges us to throw away the blinkers and to explore the challenges of macro categories such as race, class, and gender and also to burrow down to seek understanding of meso and micro levels of activity. Following Barbara Rogoff (1995), Jennifer Gallo-Fox offers another approach called multi-planar, multi-analysis for exploring sociocultural issues with the implementation of coteaching as a model for teacher education. Gallo-Fox proposes a methodology that applies multiple analyses to different planes of development including community, interpersonal, and personal. In her chapter, Rowhea Elmesky shows how a finely nuanced microanalysis of video of interactions in science learning environments can be used to identify patterned actions that are often habitual. She argues further that video microanalysis can allow us to note when disturbances or synchrony in emotions and cognition is embedded in classroom interactions, which has implications for how teachers and students can work together to optimize cognitive development.

Bronwen Cowie argues that a sociocultural approach to assessment requires educators to be mindful of the complex interaction between learning, identity, and assessment rather than an emphasis on validity and reliability of assessment tasks, which is the norm when learning is conceptualized as a thing. Using examples from classroom studies, Cowie shows how assessment, as a sociocultural activity, needs to instantiate an ethic of care, equity, and active participation of students in assessment. Focusing on the field of sociocultural research, Malgorzata Powietrzynska explores how mindfulness can be used to support people, like teachers and students, to be more aware of the relationship between emotions and actions. She explores the nature of mindfulness as being in the moment in a nonjudgmental way. In her chapter, she describes the development of mindfulness heuristics that help people become aware of, mindful of, their emotional state and its physiological markers in the moment which could help both teachers and students regulate their emotions, particularly important for an emotionally charged profession like teaching.

Charles Max, Christina Siry, and Martin Kracheel focus on context as they use semiotics to examine how science emerges from young students' interactions with material objects such as water. They note the, sometimes unacknowledged, contribution children make to research that explores the intersection between different activity systems. Of course, we understand that in contexts, like classrooms, which constitute formal approaches to education, children have already lived through a

great diversity of experiences before finding their way to a classroom. Such experiences provide a context for Gillian Bayne and Romil Amin to examine how the use of whole-class cogenerative dialogues can provide a space for English language learners to voice their needs as learners and collaborators. We just have to listen and act.

Both Giuliano Reis and Konstantinos Alexakos present "practitioner's narratives," to use Reis' term, to explore their own experiences of the body and emotions in becoming a science educator. Through autobiography, Alexakos explores the challenges and affordances of concurrently being a teacher and researcher. Cristobal Carambo also uses elements of autobiography while critically examining the theoretical limitations of research that only focuses on the institutional components of schooling and theorizes learning as an individualized rational activity. According to Carambo, what this type of research ignores is the social, cultural, and historical factors that conceptualize the learning of inner city urban youth living in communities that have been marginalized and impoverished by broader economic and political policies. He argues that methods such as cogenerative dialogues and an appreciation for the role of emotions can help to provide more equitable educational experiences for youth poorly served by purely rational individualist approaches. The construct of identity is one of the cultural elements that can be slippery from a sociocultural perspective. A bit like a Newtonian solid, the harder one holds on to it, the less definite it seems to be. Lilian Pozzer-Ardenghi and Phoebe Jackson accept that identity can be variously theorized and argue confusion can arise when researchers apply various theoretical perspectives for identity in contradictory ways with implications for inconsistencies between theory and methodology.

In their chapter, Donna DeGennaro and Tiffany Brown explore the discourse around difference and "the other." Using analytical frames from cultural studies and critical pedagogy, they question whether youth engagement with activities such as the creation of digital stories liberate or reify conditions of difference. Finally, Catherine Milne explores the ontology and epistemology of virtual and actual environments making use of Gilles Deleuze's (1994) reflections on the realness of both the actual and the virtual. She finds that both the actual and the virtual provide rich contexts for sociocultural research as the chapters in this book illustrate vividly.

New York, USA Catherine Milne

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Part I
The Experiential in Education Research

Chapter 1
The Sociocultural Turn in Science Education and Its Transformative Potential

Kenneth Tobin

When Springer Publishing agreed to create Cultural Studies of Science Education (CSSE), Wolff-Michael Roth and I successfully argued there was a pressing need for a science education journal to provide an alternative to mainstream fare. We considered the major science education journals to be much the same as one another; four or five journals differing mainly in terms of relative prestige, but publishing similar material. We made the case for a different type of journal to publish scholarly articles that would provide a concentration of research that utilized sociocultural frameworks, thereby expanding access, visibility, and legitimacy to research with a sociocultural orientation and positively impacting the status of a marginal strand of science education. In approximately a decade since the journal began to accept manuscripts more than 1,000 pages per year have been published in CSSE. These publications highlighted difference as a resource for learning within a spectrum of sociocultural theories and are reflective of editorial policies and intended practices to enhance the quality of research and avoid many of the ambiguities and contradictions associated with publishing work in mainstream journals. The availability of CSSE as a journal that requires publications to address sociocultural theory explicitly has expanded and concentrated literature in this focus area. Notably, CSSE's presence has not prevented science educators with a sociocultural orientation from publishing their work in high-impact journals such as the Journal of Research in Science Teaching and Science Education.

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A Sociocultural Turn in Science Education

It comes as no surprise to science educators that theories change the way we experience the world. Knowledge of science can certainly add to the aesthetics of everyday life as evidenced in activities such as gazing at the sky on a clear night, walking on the beach at dusk, and recording a video with the latest iPhone. As our expertise grows in a field we are privy to an expanding repertoire of interpretive frames for being in the world. Learning other discourses enriches our experience of new phenomena and provides alternative insights i.e., making the strange familiar and the familiar strange. In this context I address some of the sociocultural perspectives I have employed in my research in the past 20 years as affordances for experiencing, describing and researching the landscape of science education.

Polysemia is a powerful construct that acknowledges people's social positioning in the world as primary frames for what is regarded as socially true. Having accepted a polysemic stance it behooves us not to judge from outside a framework, but to endeavor to step inside to understand what is happening and why it is happening from the perspectives of an insider – that is, to adopt an emic perspective. Being a science educator from the early 1960s until now has given me an inside seat into ways in which mainstream perspectives of what counts as science have marginalized many discourses, which are often regarded as nonscientific (e.g., indigenous knowledges). In this way, the domain of science education can be impoverished and may not connect with everyday life experiences of important stakeholders. As we face grand challenges associated with issues such as sustainability and wellness the question of what counts as science education has never been more important. Adopting a polysemic stance, there are advantages in thinking about science broadly, looking at other discourses from the perspective of what they afford; how they can open up possibilities for science education and thereby enhance the quality of life. By expanding the vision of what counts as science education, roles of science educators can be enhanced, increasing possibilities to connect in important ways to problems faced by humanity, other species, and better understanding networks of social relationships that can sustain and nourish a fertile and hospitable universe.

In Search of Interpretive Frameworks

My research focus from 1973 onwards was on the quality of science teaching and related challenges associated with becoming an effective science teacher i.e., learning to teach. I searched for theories to illuminate teaching and learning in classrooms and for research designs that allowed researchers to study educational problems that were meaningful to those with the highest stakes in education. Unless meaningful research could be undertaken it seemed pointless to do it.

Accordingly, my first study in science education began a quest to identify and use powerful theories that would make a difference to the practice of science education. The search began with Piaget (1964), researching psychological models to probe how teaching could enhance learning, taking account of differences in students' formal reasoning ability. The models were interesting, especially as they became more complex. After all, teaching and learning of science are complicated processes. However, there were many dissatisfiers associated with pervasive, ever-present, tenets of positivism that saturated the common sense of doing research. These included, but certainly are not limited to, the reductionism of parsimony, tightly defining variables, testing a-priori hypotheses, and assuming independence of learning from the social milieu. Assumptions such as these were contrary to my experience as a teacher and hence, from the beginning, I looked for ways to complexify my research. Initially this was done through the use of increasingly more sophisticated statistical models.

The positivistic models that provided a foundation for my process-product research in my first decade of research (i.e., from 1973) were oversimplified; reductive, and assumed that learning could somehow be accomplished independently of others. Furthermore, assumptions made to justify the use of inferential statistics and associated statistical generalizability could not be accomplished and arguments to the effect that violations of assumptions were insignificant were unconvincing (Tobin and Capie 1982). I was in search of new methodologies and theoretical frameworks to make sense of teaching and learning. The search for more appropriate frameworks was arduous, continuous, and unbounded – now spanning more than three decades (Tobin 2012). Even so, my experience is that positivism was, and still is, dominant – as crypto-positivism, which saturates what the mainstream regards as common sense, especially as it applies to research methodology (Kincheloe and Tobin 2009).

A less visible problem was the dominance of psychological models in educational research. My early studies assumed learning to be primarily an individual endeavor. Accordingly, the models I adopted examined relationships, for example, between the teacher and the student, as if participants were independent. What teachers did was assumed to be primarily due to their knowledge of teaching. Similarly, students were considered to learn science with the assistance of teachers, in a process of making sense of what teachers say and do, what they know already, and resolution of cognitive conflicts en route to conceptual equilibrium. I struggled to identify and create models that regarded learning and teaching as social processes – involving more than individuals being in a social context. What was involved was an effort to understand and apply theories of Pierre Bourdieu (1992), Lev Vygotsky (1962) and Mikhail Bakhtin (1986). Within the science education fraternity new scholars, including Wolff-Michael Roth, William Cobern, and Angela Calabrese Barton were getting started and bringing with them a range of perspectives grounded in sociology (Roth 1995), anthropology (Cobern 1993), and social justice (Calabrese Barton 1998).

Studying Social Phenomena

Several theoretical rationale framed my ongoing research, including a methodology that was saturated with crypto-positivism and a theory of learning that reflected individual constructivism. Differences between frameworks raised contradictions, which became drivers of change, especially those that juxtaposed positivism and constructivism. I employed hermeneutic phenomenology and ethnomethodology as frameworks for interpretive research. At a crypto level my approach incorporated a Geertzian theory of culture (Geertz 1973), which was embedded in Frederick Erickson's interpretive methodology, and polysemia, which became a catalyst for ongoing change when I adopted the authenticity criteria from fourth-generation evaluation (Guba and Lincoln 1989). The criterion of ontological authenticity addressed polysemia and encouraged me to re-examine purposes of research and especially relative interests of different types of participant.

The quest for a scientific method and social theories that are universal, parsimonious, and empirically verifiable disallows many tenets that underpin my research. For example, we[1] regard difference as a resource for learning and a central characteristic of ways in which social life is experienced, whether it is in research, other aspects of professional life, or everyday life. Since we theorize contradictions as ever-present, a consistent aspect of our research is to search for contradictions and learn from them, thereby expanding what can be learned from the research (Tobin 2009a). Furthermore, rather than search for one social truth, we consider social life to be characterized by multiple truths, most phenomena being polysemous. Consistent with this view we accept positivistic research and seek to learn from it – ironically, those who embrace monosemia may not accept the legitimacy of research such as ours. Accordingly, research with a non-positivistic orientation might suffer in peer-review, can be ignored when it is published, and is likely to have less impact on policy and other aspects of professional education. Positivism has penetrated social life to such a degree that it saturates common sense arguments and supports oversimplified aspects/versions of scientism (Kincheloe and Tobin 2009).

Because of our research interest in the teaching and learning of science, the sociocultural turn in science education had impacted our thinking in the early 1980s. An emerging set of sociocultural theories that we employed in our research in urban education embraced a view of culture that was post-Bourdieusian (Sewell 2005). William Sewell Jr., a historian who grounded his work in cultural sociology, expanded the work of Pierre Bourdieu (1992) and Anthony Giddens (1990) to produce a multilogical framework we adapted for our research on learning to teach, and teaching and learning science (Tobin et al. 2005). Sewell explained how actors experience culture as schemas and practices that have thin coherence and ever-present contradictions. What this meant for us is that when culture is experienced

[1] I use the pronoun we from here on to acknowledge that my research and associated theorizing involved others – throughout my career. Obviously this extended far beyond publications and includes conversations of many genres (e.g., dialogue, argument, lecture).

there will always be patterns that can be observed along with contradictions to those patterns. That is, the contradictions provide nuance to descriptions of culture, and can be experienced by social actors as resistance.

Our focus on culture was associated with field – a social space in which culture was produced continuously in a dynamic structural flux consisting of symbolic, social, and material resources. In theorizing the urban context it was important to examine how culture from multiple fields provided resources for activity in a focal field such as science education. This theoretical interest pushed us to relate characteristics of electric, magnetic, and gravitational fields, in a metaphorical sense, to social fields. We began to see the desirability of fields being unbounded entities and field strength being related to the distance of social actors from the "center of mass" of a given field. In this way it became progressively clearer how resources associated with fields like the home, recreation, hobbies, and employment, for example, were salient to learning science. To some degree this brought into focus the importance of cultural and other forms of capital and the rich and continuous structural flux that flowed through fields.

The sociocultural methodologies we find most useful in social inquiry parse social life and associated experiences in terms of constructs we consider to be constituents of a whole. A dialectical relationship is assumed between the parts – i.e., each is recursively related, presupposes the existence of the other, does not exist independently of the others, and does not precede the others temporally. As constituents, dialectical components cannot be aggregated to stand for the whole, but instead under represent it (i.e., the whole always exceeds the sum of its parts). We use a Sheffer stroke between constructs to show a dialectical relationship (e.g., individual | collective). If more than two constructs are dialectically related we use the term multilectical to refer to the relationships between all possible pairs of the social constructs being considered (Fellner 2014). The incorporation of multilectics into our methodological framework made a big difference to the design and conduct of research. For example, the individual | collective relationship implies that anything associated with an individual is at the same time interconnected with the collective. That is, an individual's enactment of culture in a field must be considered along with collective enactment of culture in the same field. All cultural enactment is both individual and collective. Similarly, the self and other are dialectically related. From this perspective any property of self is dialectically interconnected with properties of non-self and other. Accordingly, a construct like identity can be considered dialectically in relation to salient features of non-self.

The dialectical way of thinking necessitates changes in how we plan and enact research, in all its phases. For example, what we learned from research could be expressed in terms of cultural production (i.e., enactment) and would necessarily include schemas and practices, all claims being represented in nuanced ways that describe culture in terms of patterns having thin coherence and contradictions that are ever-present. Furthermore, cultural production in social interactions reproduces culture while transforming it (i.e., reproduction | transformation).

We regard knowing as cultural enactment, being experienced by social actors as schemas and practices, which are dialectically related (i.e., schemas | practices). By

enacting reflexive practices, social actors become aware of aspects of their conduct that they may not have been aware of previously, creating possibilities for intentionally making changes for the purpose of improving the quality of social life. That is, exercising agency in a conscious, goal directed manner could change practices. New forms of culture can be enacted by appropriating structures, which are transformed in action. The enacted culture then becomes part of a dynamic flux of structures that are available to be appropriated by any of the participants in a field.

Agency, as a conscious process, can only account for part of continuous cultural production. As structures penetrate a field they produce culture in a non-agentic process in which production occurs continuously as actors participate with others in a field (Roth 2007). The process, described as passivity, is appropriated from the work of Emmanuel Lévinas (1999). Following Martin Heidegger (1996), we employ the mantra of "becoming like the other by being in with," incorporating the idea of learning by being in a field at the elbows of others (Tobin and Roth 2006). As Michael Juffé pointed out, passivity can be a misleading term, since the essence of what is involved is receptivity to learn from others, including social artifacts (Juffé 2003). Accordingly, it is useful to think of passivity in a dialectical relationship with structures, agency, and a necessary ingredient in production. That is, production always consists of agency | passivity. We also employ other useful dialectical relationships, appropriating key ideas from activity theory (Roth and Lee 2007). These include individual | collective, goals (of individuals) | motives (of collective), and action (of individual) | activity (of collective). Consistent with multilogical methodology, additional theoretical entities are considered if, when, and as necessary. We employ an expansive heuristic whereby constructs can be understood through the way we use them in our work – the meanings of social constructs, such as field, emerge from our uses of them in the research (i.e., meanings in use).

Hijacking Science Education

My journey away from positivism was arduous, largely because tenets of positivism have saturated common sense in the Academy. It was quite common for peer-reviewers to apply tenets of positivism in their reviews and request changes they felt were needed to strengthen my work – that I align submitted papers with tenets they accepted as true. Accordingly, in order to publish our work, we had to respectfully address issues such as objectivity, sample size, statistical generalizability, and parsimony even though we did not always accept such premises as viable. Also, published research, from the mainstream, was frequently accepted as true (or known) and this made it difficult to present alternative perspectives and associated visions as salient priorities for research, policy formulation, and changed practices.

The mainstream has in several ways taken control of what is, is not, and can be regarded as science education. Several years ago, after delivering a keynote address at a science education conference in Barcelona, Spain, I was confronted and intrigued by the audacity of another of the keynote speakers, a person I would regard

as a learning sciences scholar, who suggested that my research on emotions and urban education, though grounded in the teaching and learning of science, were not legitimate studies of science education. His act of labeling was one of marginalizing my work. His argument was that what we learned was applicable to any of the curriculum areas – not especially to science education. This has been a familiar, though flawed and imperialistic perception of science education that, in my view, contributes to the reproduction of pervasive and ongoing problems. This person expressed a mainstream view that is damaging, not only because it allows him to ignore my research, as if it were never undertaken, but because he can also classify other studies of teaching and learning as irrelevant to science education because they are applicable to other curriculum areas.

Unfortunately, the view of this colleague is not confined to just one or two individuals. For example, at a recent meeting of the National Association for Research in Science Teaching, as I listened to a keynote address delivered by a leading scholar in the learning sciences, I noticed numerous possible connections to our ongoing work. However, she seemed unaware of research that was outside of the conceptual change/individualism framework – not only to our projects but also the work of others who adopted a sociocultural perspective. I wondered whether this failure to connect and acknowledge would be tolerated in the natural sciences and felt a rising tide of emotion-based on an articulated belief that her failure to acknowledge and learn from our research was a sign of poor scholarship and more generally a deep malaise in science education. This person, like the guy in Barcelona, was selected because of her perceived eminence and anticipation that she would inspire and shape research in science education. However, to me, her presentation was just another example of parochial, self-serving research in a mainstream that is increasingly irrelevant and inward looking.

Acknowledging and learning from difference is a central issue for science educators to address, irrespective of the categorical labels each scholar might apply to him/herself. Multilogicality is here to stay and the field of science education cannot afford, and should not allow its scholars to ignore, silence, and discredit research that is grounded in different systems of logics. It is not so much that every pathway has equal claims to viability; it is just that, as a way of illuminating social life, affordances provided by a given framework might not be visible through other frameworks. Failure to look and see alternative visions might direct science education to a pathway headed toward extinction.

The gold standard in educational research was presented to me in my doctoral program, back in the late 1970s, as an experiment – a study that included random assignment of objects/subjects and employed a design that was protected by internal and external generalizability. Unfortunately many tenets associated with experiments are used to judge research that is not experimental and that eschews the logics of experimental research. For example, we regard those who participate in research as social beings who are unique – we do not see them as objects or interchangeable subjects. Accordingly, we do not do research for the purpose of generalizing to others like those involved in the research (Tobin 2009a). Instead we regard the purposes of our research as learning more about theories and creating toolkits for promising

practices that potentially can be used by those who see possibilities and choose to use the toolkit, as is or as adapted (Eisenhart 2009). Similarly, theory production is an affordance for seeing social life differently, including problems and possibilities. New theory is part of an expansive agenda that opens up conversations about social life.

How can you generalize from an n of 1? This question and the heavy-handed criticism that goes with it are usually delivered courtesy of blind review. An assumption in the question is that participants in a study are a sample selected from a population (i.e., n stands for sample size). The n is expected to be representative of N, which stands for the size of the population. Statistical generalizability usually necessitates random selection and random assignment to groups. In our research this is never the case since we select participants who are accessible, educated about the research, and chosen because we expect to learn from them. In fact, participants are invited to join a study serially, contingently, and explicitly because of their differences from one another. Purposefully selecting participants is not regarded as weakness – it is a feature of research methodology that is responsive to contingencies. As a result the design of research is necessarily flexible and continuously in flux as we learn and decide what is best to do to learn even more (Tobin and Ritchie 2011).

Sometimes the question of selecting participants is framed in terms of cherry picking – that is, we select participants to provide the results we get. To some degree this is exactly what we do. However, we adhere to the criterion of ontological authenticity whereby each researcher seeks to change his/her ontology as a result of learning that occurs in the research. We do not ascribe to research where hypotheses are formulated in a directional sense between variables and a study is then set up to test those hypotheses. Instead, research we do involves hermeneutic phenomenology. We seek to learn expansively from lived experiences of all participants and we design our research to ensure changes in the subjectivities of all participants, including researchers (Tobin 2006). Whereas we select participants who can provide the kind of information we are looking for, we do not begin with a-priori hypotheses that are tested. Instead, what we learn emerges from ongoing research and is nuanced and polysemic. When contradictions are observed we make every effort to learn from them and certainly do not pass off differences as unimportant. The patterns of coherence that emerge are an important outcome of research and so too is nuance, which takes the form of contradictions to any patterns of coherence that are experienced.

Structure of the Remainder of the Chapter

The remaining sections of the chapter address some of the milestones passed on the way to our present research practices. These include interpretive inquiry, authentic inquiry, event-oriented inquiry, interventions, expanding horizons for science education, and expanding horizons for science education.

Interpretive Inquiry

Our search for a viable framework for improving research in science education led to Michigan State University, where Erickson had just completed an advanced draft of a chapter on interpretive research – to be published in 1986 (Erickson 1986). This meeting with Erickson turned out to be most fortuitous and within a short time we were adopting and adapting interpretive research methods as a primary methodology for our research.

We were intrigued by Erickson's description of interpretive research as an umbrella term for participant observation because it explicitly addressed and acknowledged subjectivity as a strength of interpretive research. Furthermore, the necessity to address what is happening and why it is happening from participants' perspectives immediately raised serious issues about how to deal with differences of perspective. Not so apparent was a related issue of not privileging any voice in interpretive inquiry. Initially the methodology seemed to apply writ large to researchers like us, who were university-based – a reminder to silence our voices. However, soon we realized that, as participants, our voices were important and should be considered along with others' voices from each of the stakeholder groups. Interpretive inquiry was designed to be polyphonic, providing opportunities to learn from many voices. Just how polyphonia was to contribute to high quality research in our project was yet to be worked out, but it was clear that no stakeholder group should be omitted or deleted and no stakeholder group should have a privileged voice. Complexity and difference were as much a part of interpretive methodology as coherence.

The tenets of interpretive research were strikingly different than those of traditional positivistic-oriented research, which tended to identify central tendencies and consider deviations from the center of mass as errors or anomalies. In contrast, in interpretive research the approach was to understand and explain deviations from central tendencies, or assertions defined by patterns having thick coherence. Interpretive inquiry embraced a theory of culture based on the work of Clifford Geertz, an anthropologist (Geertz 1973). From this perspective, explaining the exceptions was just as important as explaining central tendencies.

Having accepted that all research involves participant observation and that the presence of the research and researchers make a difference, there seemed little to be gained from convincing others that differences made by research were negligible. First, it is impossible to tell what would have happened in the absence of research and, second, offering an explanation might inadvertently reinforce the idea that subjectivity is a weakness of research design. On the contrary, subjectivity can be regarded as a distinct advantage that generates many possibilities for improving the quality of research.

Authentic Inquiry

Using a particular theory can be generative of new issues to resolve because of novel ways of experiencing. Accordingly, questions, answers, and possibilities unfold. Within the framework of authentic inquiry we seek ways to improve equitably at collective and individual levels.

Egon Guba and Yvonna Lincoln (1989) incorporated a constructivist perspective into what was then an exciting new evaluation methodology. The approach broke free of shackles of positivism and advocated criteria for judging quality of an evaluation in terms of ethics and what they referred to as authenticity criteria. The methodology appealed as highly appropriate to our research in the 1990s and we adopted and continuously refined the authenticity criteria and associated "fourth-generation evaluation" to meet the needs of our ongoing research in science education. We refer to the approach as authentic inquiry, which employs research designs that are contingent, emergent, and dynamic. Theory and changed practices are both outcomes from participation in authentic inquiry. As our research projects developed from the 1980s onward they incorporated both interpretive and authentic inquiry as methodologies that tended to supplant approaches often described by the data resources used in the study (i.e., qualitative, quantitative, mixed). However, the trajectories of changing methodologies were steep and reflected growing emphases on sociocultural theory.

Changing Perspectives on What Is Happening

Authentic inquiry addresses additional values concerning ethics, and acknowledges that knowledge is inherently political, reflecting participants' positions in social space. According to this methodology, what is learned from research does not constitute a unique social truth but instead is saturated by lived experiences. To the extent that participants do learn from one another, their descriptions of what is happening and why it is happening also differ. We consider such differences as valuable resources in research – providing insights into different ontologies. We do not regard perspectives that cohere as correct and contradictions (i.e., not conforming) as mistakes. Rather, different perspectives can reflect different positions of participants in social spaces–mediating lived experiences, learning, ontologies, and social realities. We accept social life as polysemic, characterized by many social truths/realities. Furthermore, as researchers, we value the importance of learning about and from others' realities, or ontologies. Rather than a small number of privileged university-based researchers learning from doing research, authentic inquiry anticipates that all participants should change their ontologies as they participate in the research. That is, participants would change the stories they tell about the fields of social life being researched. From a design perspective research can examine the extent to which progressive subjectivities occur within salient stakeholder groups progressively documenting participants' changes in ontologies and conduct.

Becoming Self-Aware and Learning from Others' Perspectives

Educative authenticity affords participants learning from one another's ontologies without seeking to change perspectives that differ from their own. Educative authenticity regards differences as learning resources and assigns high value to each individual's rights to be (and remain) different. That is, participants in all stakeholder groups (e.g., researchers, teachers, students, school leaders, parents) can learn from their active participation in a study. This criterion acknowledges different participants having different goals and associated perspectives on what is happening and why it is happening. To address this criterion it is important to identify outcomes valued by different participants and ensure that research design has sufficient malleability to study varied goals and diverse levels of success and benefits from participation in research.

Catalyzing Institutional Change and Equity

Through learning it is possible that positive changes can occur to participating individuals and institutions. Authentic inquiry acknowledges that participants are not equitably placed to gain advantage by participating in research. Researchers accept an obligation to help those who are unable to help themselves to benefit from participating in research. Once the educative potential of participating in research is realized then designs can be planned and enacted to maximize authenticity in terms of education, catalyzing institutional changes, and ensuring that all individuals benefit equitably from being involved in research.

An increasing emphasis on authentic inquiry, as a component of a multilogical bricolage, heightened our awareness of the importance of both creating new theories and applying them to improve the quality of the aspects of social life being studied – in our case teaching, learning, and learning to teach. Accordingly, a major outcome of our research was the creation and testing of interventions that could be components of toolkits others might use to improve their practices. I address this important aspect of our research in a section of this chapter in which I address interventions.

Event-Oriented Inquiry

Our acceptance of difference as a resource for transforming culture and learning from research translated into a gradual shift in our ways of thinking about and doing research. To an increasing extent we viewed contradictions as an expected feature of social life – not an inconvenience that needed to be explained away before we could conclude a study. Furthermore, because of a dialectical relationship between

reproduction and transformation, we began to view contradictions as seeds for social change. Accordingly, as an essential component of our multilogical approach to research, we embraced identification of contradictions and associated changes in patterns of coherence (Tobin 2008).

Fortunately, Sewell had articulated event-oriented inquiry in the context of historical research, searching for and interpreting contradictions in macrostructures in his studies of historical events such as the French Revolution. We adapted event-oriented inquiry to our multilevel research in science education. We regarded a contradiction as a spike in the curve, something important that was against the grain. For contradictions of interest we identified and contextualized associated events and the episodes of social life that contained them (i.e., for each contradiction we identified an associated event and the episode in which it was contained). We then adopted a hermeneutic phenomenological approach to describe what happened and why it happened during episodes, seeking to capture the salience of the event, which was then further analyzed using multilogical and multi-method analyses.

Randall Collins' framework heightened sensitivity to synchrony and entrainment, which we began to consider in terms of resonance and passivity (Collins 2004). When Michael Roth and I first started to apply this framework I remember standing near an elevator at the University of Pennsylvania, looking back at clusters of people in a cafeteria. As we surveilled a landscape of numerous groups we observed synchrony and asynchrony in changes in orientation and movement of the body (i.e., including fingers, hands, arms, shoulders, torso, and legs), head, eyes, and facial expressions. Patterns were observed at moments in time and across intervals of time. From this time forward our collaboration on urban science education began to include descriptions of culture that examined patterns and contradictions in proxemics, within a framework of interaction ritual theory.

Our research in urban schools revealed just how central expressed emotions were to teaching and learning specifically and to social life more generally (Tobin and Llena 2011). At every instant emotions were enacted as part of cultural production – including curricular goals such as science learning. At times emotions were intensive and their presence catalyzed interaction chains that disrupted teaching and learning. In fact, there were instances of angry outbursts that alerted us to the fact that intense emotions might be damaging to the health of teachers and students. We wondered how intense emotions related to physiological factors such as pulse rate, oxygenation of the blood, blood pressure, and body temperature. Our ongoing research revealed that our fears were well grounded. Teachers and students might protect their wellbeing if they had strategies for ameliorating intense emotions. Our research on physiological expression of emotion confirmed many fears we had about teaching and learning. Most urban classrooms we studied and otherwise experienced in our professional lives were highly toxic for teachers, who expressed intense emotions in terms of heightened blood pressure, high pulse rate, and low percentages of oxygen in the blood. From the perspective of authentic inquiry we felt an ethical obligation to intervene to improve the quality of life for the participants in our research.

Research on the intensity and focus of emotions has implications for teaching science. For example, during a lesson on conversion of units a teacher and several students were frustrated with student performance on a recent quiz (Tobin and Llena 2011). The teacher had been absent due to illness and a substitute had been teaching the class. Students were having difficulty following the teacher's efforts to re-teach the work. As a student leant across to clarify for another student the teacher reprimanded her for speaking while he was speaking and an altercation broke out. In many respects the learning environment became dysfunctional. The teacher's focus on his anger was intense and he represented anger through his gestures, prosody, and semantics of the spoken text. Consistent with intensity of emotion increasing focus, the teacher was less able to attend to teaching students about conversions from one unit to another (e.g., liters to milliliters). His oral presentation was slow, contained long pauses, and included utterances about "rude student." In many respects the text was unintelligible, becoming an object for humor and ridicule for some students who regarded the altercation as a performance, and laughed at what was happening. For students who had been reprimanded, phrases such as "rude student" were inflammatory and catalyzed further outbursts, ratcheting up the intensity and distribution of high emotions.

A significant publication that employed event-oriented inquiry was situated in Philadelphia (Roth and Tobin 2010). The study was multilogical, involving video analysis and an approach to research that featured the use of students as researchers in their own classes. On this occasion several youth reviewed a video and selected a short vignette they felt was an example of a good approach to learning. Multiple methods employed in the study included conversation analysis, prosodic analysis, proxemics, and facial expression analysis. Interpretively we examined relationships among constructs such as power, synchrony, solidarity, and interaction chains. When it came to proxemics we focused to some extent on rhythm. Classroom interactions seemed to have a rhythm represented in synchrony between prosody and proxemics. Our efforts to capture the essence of the rhythm looked at patterns and contradictions evident in head nods, leg and hand movement, peaks in the intensity of talk, and clicks made by chalk on the chalkboard. Adopting the idea of resonance we looked at classroom participation in terms of students tuning into this prevailing frequency (i.e., the rhythm of the classroom) in order to successfully interact.

Interventions

Authentic inquiry addresses the moral aspects of doing research. For example, it is not appropriate to do research that identifies problems without endeavoring to resolve identified problems. As we learned more about collaborative approaches to teaching and learning, such as cogenerative dialogue (cogen) and coteaching, new pathways for enacting curricula emerged. Even so, we experienced dysfunctional classroom environments in which teachers and students exhibited intense emotions. Circumstantial evidence raised concerns that intense emotions were deleterious to

the health of teachers and students. For example, one of the teachers in our research had heart disease that we connected to his anger – that we felt occurred too frequently. Teaching and learning should not make participants sick and it behooves researchers to do more than just identify problems and exemplary practices. Interventions also should be developed to utilize what is learned from the research to improve the social lives of research participants.

Based on the work of Pierre Philippot, Gaëtane Chapelle and Sylvie Blairy (2002), we knew of relationships between breathing patterns and emotions. That is, emotions could be changed by changing the pace and depth of breathing and also emphasizing the diaphragm or the belly while breathing. Also, as emotions changed, so too did breathing patterns. Accordingly, we decided to use breathing meditation at the beginning of lessons to ameliorate emotions. The benefits of breathing meditation were well documented in the literature and they began to be apparent in our research. Similarly, another tried and tested intervention involves reflexivity – becoming aware of the unaware. We adopted this principle in the design of a number of heuristics to make participants in education (e.g., teachers and students) aware of characteristics of constructs we regarded as salient to improved teaching and learning. As examples of our uses of heuristics, in this section of the chapter I present mindfulness and mindfully speaking. These are examples from heuristics that have been developed for cogen, coteaching, radical listening, mindfulness, mindfully speaking, and mindfully listening.

Mindfulness

Our research on emotion and growing evidence of students getting stuck with an emotion, which then mediated their ongoing conduct in deleterious ways forged a pathway into research on being in the moment–our mantra for mindfulness. Our goal was not so much advocating for mindful practice, as it was to heighten participants' awareness about its salient characteristics. The rationale was that knowing the characteristics of mindfulness would provide windows into the practices of self and others, opening up possibilities for considering changes in conduct if and when it was deemed desirable by particular stakeholders.

We developed a heuristic that consisted of short descriptions we considered salient to the circumstances of our research. We thought of the heuristics as shape shifters, in that characteristics would change to reflect the context, which was continuously changing. Some of the key components of mindfulness were maintaining focus, being aware of what is happening, minimizing attachments of ongoing conduct to emotions, and showing compassion to self and others. Because of our interest in wellness and emotion we included characteristics associated with pulse rate, body temperature, breathing patterns, and emotional styles (e.g., resilience). Some of the characteristics included in the heuristic are: I am curious about my feelings as they rise and fall; I can tell when something is bothering other students; I find words to describe the feelings I experience; I am aware of my emotions as they are reflected

in my face; I identify distracting thoughts but let them go (without them influencing future action); the way in which I express my emotions depends on who is present; I am not hard on myself when I am unsuccessful; I can focus my attention on learning; the way I position and move my body changes my emotions; and I recover quickly when I am unsuccessful.

Mindfully Speaking

As a form of action, speaking is a way to represent what is known about the topic of discussion. In dialogue with others, speaking aloud allows a speaker to represent what s/he knows, for others to listen and make sense of what is said, and for responses to be formulated for purposes such as to elaborate, expand, clarify, question, refute, and accept. Accordingly, when such actions occur there are benefits for the speaker in terms of speaking and in terms of hearing what is said after the initial talk. Similarly if there are no follow-ups to an utterance the person misses out on learning from a response – or putting it another way learning from others' talk. In dialogue it seems as if a turn at talk is an opportunity to represent what is known and thereby to learn through action and then to receive responses to what has been said, which creates further opportunities for learning to occur. If the focus remains on what is being said originally then successive turns at talk become resources for speakers and listeners to learn from one another. The value in symmetry, when it comes to speaking, is that every speaker has a chance for the double benefit of acting through speech and acting through listening to others' responses to what was said.

When interacting with others it is important to understand their perspectives, build respect for what others believe and value highly, and regard others as resources for personal learning. Whether the dialogue involves a Shakespearean play, how to cook a kimchi pancake, or using the subway to get from Grand Central Station to New York University, dialogue will necessarily involve a balance that reflects turns at talk and time of talk. The distribution among participants in the dialogue should be relatively equal for a given topic of conversation.

Mindfully speaking involves speakers monitoring the amount of time they have been speaking and the number of turns of talk they have had in relation to others involved in the dialogue. A mindful speaker would wind up a talking turn if and when the amount of time starts to exceed the bounds of what is reasonable. This can be accomplished by transferring the speaking turn to another speaker, preferably one who has not spoken on the topic or has not contributed equitably. Rather than speaking excessively a speaker shows his/her awareness of the value of sharing talk by involving others and thereby to maintaining balance. An important indicator of whether the amount of talk is becoming excessive is the emotions represented in the faces and body movements of others. If speakers carefully monitor others' actions as they participate in dialogue as listeners there can be signs that it is time to transfer opportunities to talk to others rather than continuing to speak. When the signs of

others' emotions are such that their interests are waning the speaker can adopt a strategy of opening up the conversation, leaving the decision of who will speak next to the group as a whole, or s/he can redirect the turn of talk to an individual. By monitoring others' emotions information can be gleaned about their levels of comprehension, their interests in what is being said, and the synchrony of their emotional responses with the present utterance/speaker and the topic of dialogue. When asynchronies occur it is important to understand them and act appropriately.

As well as monitoring others' emotions it is important when speaking mindfully to monitor personal emotions as they emerge, taking care they do not stick to ongoing conduct, mediating what happens in a deleterious manner. Note, it is not necessary to try to eliminate emotions or to soften their intensity. What seems important is that emotions do not stick to ongoing conduct unless it is seen as important for them to continue and build. This would be true of any emotion. The undesirable feature would be that emotions would build to an extent that dialogue is disrupted and/or diverted in undesirable directions. If this occurs than strategies need to be enacted to become unstuck – that is to let the emotions go so that the focus can return to the purpose of the dialogue. In this example becoming unstuck is a repair ritual. A repair ritual involving "letting go" of emotions is just one example. Another would be when a speaker is interrupted by others' emotions or by others' actions such as gestures and body movements, verbal fillers such as umm, urr, ah, etc. When breaches in the fluency of dialogue occur it is important for the speaker to be able to repair the interaction and either continue with an utterance or transfer a turn of talk to others. A condition of mindfully speaking is to be aware that a breach has occurred and assume responsibility to repair the breach and create fluent dialogue as a condition of successful dialogue.

When a participant in dialogue shows an interest in participating orally it is important not to intentionally shut that person out. The right to speak is neither an individual nor a collective matter – instead, it is an outcome of an individual | collective dialectic. When a person signals an intention to speak, in all the ways that such signals can be transmitted, the speaker should not raise his/her voice to speak over any attempt of the other to get involved by beginning to speak. Although it might be legitimate to argue that the person seeking to speak should not speak until the speaker has finished, it is important to acknowledge the rights of a listener to contribute to dialogue when, if, and as necessary. That is, the right to speak is not preordained as an ongoing (unconditional) right of a speaker. Rather, such a right is contingent on what is happening and there need to be ways of signaling to a speaker that another wishes to participate – to take a turn of talk. Accordingly, when another signals a desire to begin a turn of talk the speaker can pass the baton, confident that s/he can contribute further a little later in the sequence of interactions. A mindful speaker should not assume that what s/he has to say is the most appropriate action in an interaction chain. On the contrary, if another wants to get involved, and it makes sense to do so, then a transfer in the turn of talk can and should occur expeditiously. Failure to transfer a turn of talk will create a breach in the flow because the signal of desire to talk can be interpreted as a contradiction or resistance to enacted culture. The conditions for fluency are that actions occur in a timely manner, are

appropriate, and are anticipatory. In the circumstance of a person signaling a desire to assume a turn of talk, a mindful speaker could act synchronously by handing over the baton to the person who desires to speak.

The following characteristics are part of a mindfully speaking heuristic – When I participate in a conversation: I act to balance the amount of time I talk; when I have been speaking too long I wind up my talking turn; before speaking I pause to make sure the previous speaker has finished; as I speak I monitor others' emotions; as I speak I monitor my emotions; when asynchronies occur I try to understand them; I try to make conversations with others successful; when breaches in fluency occur I try to repair them; I do not increase the loudness of my voice to continue my talking turn; I speak with a similar rhythm to previous speakers; I maintain the focus of previous speakers; I look for signs that others want to speak; I am aware of how long I speak; I create chances for others to speak; I act to balance my speaking turns; the loudness of my talk is appropriate; I do not speak to hurt others; and my talk shows respect for others' perspectives.

Expanding Horizons for Science Education

Our ongoing research on emotion has identified wellness related issues that might be considered central to science education. For example, when a person has excess emotions in a social setting, how can these be ameliorated? What about alleviating symptoms associated with allergies, and physical conditions such as high blood pressure, dizziness, headache, hot flushes, skin rashes, and nervous tension as it is represented in shortness of breath and speech irregularities such as stuttering? Knowing one's body might involve identification of disharmonies and/or deviations from normal and knowing how to restore harmony/equilibria. Science educators might consider whether wellness, as I have described it here, is a reasonable goal for science education. In this section I provide insights into ways in which a particular framework, in this case Jin Shin Jyutsu (JSJ), can be used to provide different experiences and raise distinctive questions.

JSJ is a knowledge system that developed over a period of several thousand years, probably originating in India (Higgins 1988). Jiro Murai, a philosopher and Buddhist monk from Japan, documented the tenets of JSJ and tutored Mary Burmeister, who carefully further developed and disseminated JSJ throughout the world. JSJ can be used as a self-help system or can be administered by others to maintain wellness while treating symptoms of illness and addressing underlying causes. JSJ has flourished in the West, mainly due to Burmeister and her students. Even so, the art is not a mainstream practice and nor is it widely acknowledged as legitimate.

From a polysemic perspective, JSJ appeals as a knowledge system that is expansive and generative. Through the lenses of JSJ questions can be asked about everyday practices in all imaginable fields of the lifeworld. To what extent do JSJ-like holds occur naturally and what are their functions? In terms of the mainstream focus

on teaching and learning in classrooms – in which emotions saturate all social interactions – there are possibilities for designing toolkits that can enhance the productivity of teaching and learning while educating a literate citizenry to use self-help procedures from JSJ to improve wellness.

JSJ as a Framework for Research in Science Education

JSJ postulates that revitalizing energy, which flows up the back and down the front of the body can become blocked at 26 pairs of Safety Energy Locks (SELs, Fig. 1.1). Burmeister noted that: "as we abuse our bodies in our daily routines, mentally, emotionally, digestively, or physically, our locking system becomes activated." There are 12 main energy pathways (known as flows) and these intersect with three major

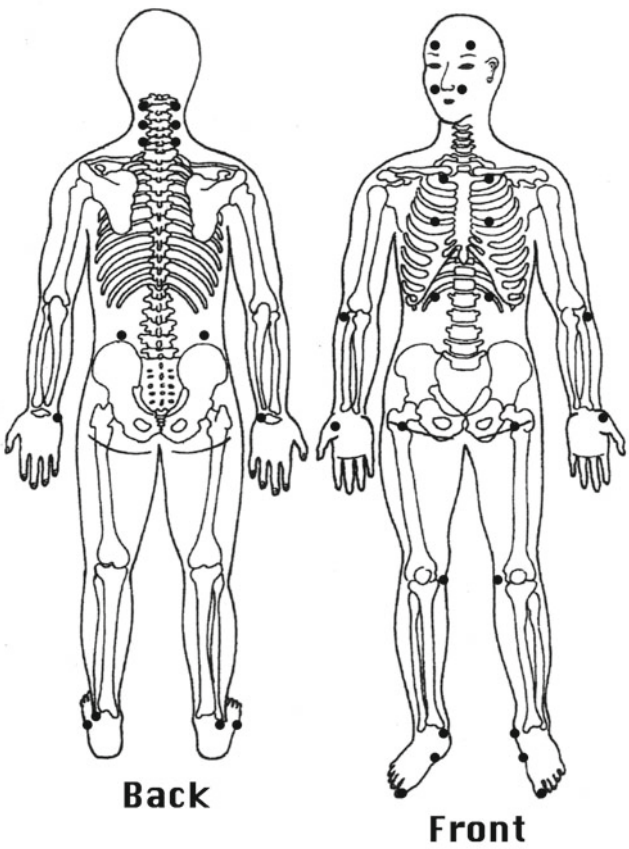

Fig. 1.1 Safety energy locks referred to in this study

flows. When SELs block, one or more flows are disrupted and associated disharmonies manifest in symptoms or vulnerabilities to disease/injury.

Each flow can be restored, or harmonized, through a sequence of light touches using fingers, hands, and other parts of the bodies. It might be as simple as grasping a finger or toe. In this way individuals can improve their own health by synchronizing pulses on their own bodies by touching/holding SELs that can be reached. People who administer JSJ open SELs by touching or holding appropriate places of the body, enabling the flow of energy to be redirected, unblocked, and recharged along energy pathways. According to Burmeister, we use JSJ routinely as we enact social life – holding hands, touching the chest, leaning on cheeks, and standing with hands on hips. But why do we do it and what do such holds and touches accomplish? We were interested to see to what extent individuals used JSJ touches/holds in different spheres of life and the circumstances in which touches/holds occurred. It is possible that when disharmonies arise a person unconsciously touches and holds SELs to restore synchronies.

I did not notice related touches/holds in day-to-day interactions until I began to practice JSJ as a self-treatment for health problems such as seasonal allergies, high blood pressure, and muscle and organ dysfunctions. However, during a recent professional meeting in Luxembourg, I was aware of individuals using JSJ as an implicit knowledge system as they touched/held themselves in ways that were identical with, or bore a family resemblance to, JSJ touches/holds. Because of my growing familiarity with JSJ and my infusion of its tenets into ongoing research on wellness, emotion, and mindfulness, I was sensitized to see and notice JSJ in people's practices. Just as Burmeister has noted, and so too have my JSJ teachers, Ian Harris and Sara Harper, touches/holds of the SELs are commonplace in every day life. For the most part these touches and holds appear to be unconscious ways of addressing physical discomforts and emotional disharmonies. In the following sub sections I address the occurrence of JSJ-like hold/touches in four contexts: a one-on-one cogen in a graduate urban education class; an oral defense associated with a doctoral degree in urban education; and a CSSE Forum in Luxembourg. Because of the interest in this paper on emotion, the interpretive aspect of these examples focuses on the use of JSJ to resolve emotional disharmonies.

One-on-One Cogen with a Graduate Student

As part of her course assessment a graduate student elected to participate in a cogen with two professors who cotaught the course in which she was enrolled. I was one of the professors. The purpose of the cogen was to create a dialogue around an oral presentation from the student. The cogen allowed the professors to ascertain what the student learned in the course and the student to show what she knew, in a context of a project she completed as part of the course. A PowerPoint presentation and nine pages of written text containing prose/narrative, freestyle writing, poems, song lyrics, diagrams/sketches, and photographs of places, family members, and friends

supported her oral text. The presentation covered aspects of everyday life in the United States (as a student, a worker, recreation, and home life), and Ecuador. Some of the text was in Spanish, but most of it was in English. To an unexpected extent the cogen was a roller coaster of emotions, which varied in type and intensity. Based on a video recording of the 20-min cogen and recollections/reconstructions of what happened, the primary emotions represented by the student involved satisfactory-happiness, disappointment-sadness, and aversion-fear. Although there may have been instances in which frustration was an expressed emotion I did not consider the assertion-anger continuum to be salient.

JSJ-like hold/touches were commonplace, produced continuously throughout the cogen. Because the camera was focused on the student, the examples provided below primarily involve SELs on the front of the body and above the table on which the student accessed her computer and notes.

Touches/holds that approximated to SELs included the following:

	In JSJ each finger connects into one or more distinctive flows of energy. Interlocking fingers from the left and right hands may be a way to harmonize the emotions throughout the body and, as necessary, return them to normal.
	The palm side of the right hand rests on the back side of the left hand. As well as contact of the fingers from the left and right hand, the SEL near the wrist on the little finger back side of the left hand and the SEL at the base of the thumb on the palm side of the right-hand are being touched by the opposite hand. Holding or touching the SEL on the back of the hand affords intuition, helping to still the mind, relax, and become peaceful, assisting to calm nerves. Similarly, holding the SEL at the base of the thumb helps to relax the body, enhance mindfulness and free the body of thoughts and worries.

	Using the fingers and/or palms to touch the SEL on the forehead above the left or right eye. Here the right hand may help to remember, focus, and clear a busy mind. It is possible that the touch initiates a calming effect.
	The fingers and palm of the left hand touch a SEL at the bottom of the cheekbone and a finger-width to the side of the nostril. It is possible that holding this SEL can relieve a sense of fear (i.e., anxiety, uncertainty, doubt) and assist in unburdening the mind and overcoming senses of lethargy and apathy.
	Folding arms with fingers extending into the inner elbow region of the arm. The hand may clutch the elbow in which case it makes strong contact between an area at the base of the thumb and the elbow. In other instances participants grasp one elbow while resting the other elbow on the back side of the other hand. In this case an SEL on the little finger side of the hand, close to the wrist, might make contact with the elbow.
	Holding an SEL on the outer side of the elbow restores harmony, thereby affording confidence and authority, providing balance and control of destiny. If a person has a sense of losing control she may well touch or hold the SEL on the elbow in an effort to gain control, not necessarily over others, but of herself. In this image the right hand may be touching the left rib cage, also a site of an SEL.

JSJ-Like Holds Exhibited During an Oral Dissertation Defense

Like many doctoral oral examinations Ali opted to present what she had learned with a plethora of PowerPoint slides to support an oral presentation. Few were in attendance. The supervisory committee of three and a friend of the candidate, a professor from a nearby university, sat quietly as they listened to the unfolding narrative of what was accomplished in the dissertation research. Occasionally one of

the committee punctuated lengthy sequences of listening with a question that sought clarification. For the most part the candidate gave a 45-min oral presentation without interruption in an articulate and fluent manner. Understandably her emotions were running high, especially those situated on an aversion-fear continuum. It was impossible for me not to notice Ali's continuous flow of JSJ-like hold/touches. Accordingly, I decided to record them as they emerged in a 5-min segment that occurred 20 min into the oral presentation.

- Held her right thumb with her left hand.
- Placed her left hand on her right shoulder, like a coat hanger hook, over her shoulder and angling toward the neck and spine.
- Placed her left hand, palms down, above her left breast.
- Placed right hand on right groin, more or less as an anchor as the left hand gestured and touched SELs.
- Place left fingers on the left cheek about a half-inch from the nostril.
- Interlocked fingers of her left and right hands occasionally elevating both middle fingers vertically (touching one another).
- Wrapped her left hand around left-hand side of neck, below skull.
- Slid her right hand back and forth from right groin to right kneecap (on the inside).
- Placed back of her left hand on the right arm, just below the elbow.
- Interlocked fingers of her left and right hands.
- Placed left palm on right palm, thereby engaging fingers and the base of the thumb on each hand.
- Placed left hand on neck to cover SELs at the base of skull and on the lower left side neck.
- Placed right hand (palm down) on the back of the right wrist, on the little finger (outer) side.
- Slid right hand back and forth on left hand and lower arm – from outer wrist to access side elbow on same side of the arm as the back of the hand.
- Place left hand on three SELs on the right neck and just below (just below skull, at nape of neck, and angling toward the spine from where the neck meets the shoulder). Ali then slid her fingers down to the front of the body into a cavity beneath the right clavicle.
- Placed fingertips of her left hand on fingertips of her right hand in a deliberative manner.
- Left thumb deliberatively works the nail of her right thumb.
- Left thumb deliberatively works on the nail on her right ring finger and then on all right hand fingers.

Although it is not an identified SEL Ali also spent time moving her fingers from her left ear down the underside of the jaw to the chin, touching that area with her fingers and the neck with her fingertips. Since SELs are three dimensional (i.e., having a diameter of about 3 inches), touching the front of the neck engages the SEL that is associated with the corresponding part of the back of the neck.

Common Touches and Holds During the CSSE Forum in Luxembourg

Photographs taken with my iPad during the CSSE Forum in Luxembourg showed that JSJ-like holds were enacted literally everywhere. Most participants touched and held SELs continuously, possibly to mediate the production of emotions – seeking to diminish excess emotions and increase emotions that may be useful in meeting goals. The JSJ framework afforded me experiencing emotions and proxemics in different ways. As the keynote speakers delivered their presentations they were standing, speaking from the front of the room using a PowerPoint presentation to support what they had to say. About 30 participants sat at benches arranged as the other three sides of a rectangle. The keynote speakers used gestures and at various times touched their faces, arms, and upper bodies in various places that were proximate to JSJ's SELs. Similarly, seated participants also touched SELs on the upper and lower parts of the body. The photographs in this section are of me to avoid the use of the pictures from the Luxembourg conference that I analyzed.

	The SEL just above the breast can be harmonized by touches of the fingers or palms. When this SEL is out of harmony it may be associated with a sense of guilt and an assumption of responsibility. Holding this SEL can ameliorate these emotions while boosting the immune system, increasing resistance to catching something from others – such as a cold or flu.
	Participants who stood up during the keynote address, including one speaker and several others, appeared to stretch and placed their hands on their backs, just above the hips. This point on the body corresponds with an SEL associated with energy flowing through the hip. Touches and holds of this SEL can relieve a sense of fatigue and minimize doubts, competitiveness, grief, and even desperation.

Seated participants were observed to place their hands and fingers close to an SEL on the groin, often moving the fingers toward another SEL located at the upper/inner side of the knee. In fact, while seated and listening, a number of participants had one hand on the groin SEL and the other on the top/inner knee.

Touching the SEL close to the groin in conjunction with a hold on the SEL on the upper knee, is common, especially when a person is seated. Touching the SEL near the groin can ameliorate intense negative emotions and produce happiness and a sense of fun. As the JSJ canon remarks, letting go of stress can be associated with laughter and joy.

As the presentations progressed several participants were seen placing one hand, like a coat hanger, diagonally across the body to clutch a SEL close to the spine, just below the neck (e.g., left hand over right shoulder while right hand is on the right upper/inner knee).

There are numerous SELs in the vicinity of the shoulder and neck. Reaching over the shoulder like a coat hanger grasps an SEL associated with worry, fear, and negative thinking. Holding the SEL can reduce negative emotions and foster positivity. In terms of physical wellbeing the SEL is associated with problems that include neck and wrist pain, headaches, and high blood pressure.

	Two other common body orientations involved one leg crossing the other at the knees. In this case and SEL on the lower/outer side of the knee comes close to the SEL on the top/inner side of the other knee.
	An SEL on the lower outside of the knee rests on an SEL on the top of the inner knee. Also, the right hand holds the SEL on the upper knee of the left leg. According to JSJ canon, it is possible that holding the SEL on the lower knee harmonizes anger and induces a higher level of tranquility. Similarly, holding the SEL on the upper knee can relieve stress, calm nerves and build self-confidence.
	Similarly, legs were frequently crossed at the ankles allowing for an SEL on the outer (little toe side) ankle to come into contact with an SEL on the outer/top arch of the foot.
	There is a SEL just below the ankle knob and the back on the little toe side rests on the right ankle. A common posture is to rest this on an SEL on the top of the outer side of the arch on the right foot, which is midway between the ankle and the little toe. Opening up the SEL under the ankle knob is associated with transformation and often catalyzes clearing of the mind and changing expressed emotions. By discarding entrenched emotions and thoughts (i.e., letting go) then fears and uncertainties can be resolved.

Research Possibilities

Based on my analyses of the prevalence of JSJ holds in everyday life, they are pervasive in diverse contexts and appear to be used to ameliorate changes in emotion and physical disharmonies as they arise. For the most par the holds/touches are fleeting and appear to be enacted without cause-effect levels of awareness. This had me thinking immediately about all of the video resources we have for our on going research on emotions. I am curious about the landscape of JSJ holds in different classroom activities. Which JSJ holds occur and what are the contexts associated with their use? Consistent with the use of JSJ as a complementary system of medicine, it seems logical to hypothesize that tacit use of the holds would be associated with emotional and physiological changes – presumably benefits. Within a context of event-oriented, multilogical, multilevel research, the applications of JSJ in science education offer an opportunity for science education scholars to expand their interests to embrace wellness across the birth-death continuum and become central in research on wellness, a major issue of our time. If authentic inquiry is part of our methodological bricolage, it is evident that what is learned from ongoing research can educate all stakeholders, improve lifestyles for different communities within society, and address the needs of individuals who are not well-placed socially to take advantage of what we learned from research.

The occurrences of touches/holds that correspond with JSJ's SELs might be regarded as actions that are potentially transformative in regards to wellness. Many questions arise as I consider what might happen, based on my very limited experiences of studying the incidence of SEL touches/holds in classrooms. The following questions serve as an example of the generative potential of the JSJ framework for research in social settings, including classrooms.

- What is the relative occurrences of touches/holds for each of JSJ's 26 pairs of SELs?
- How does the occurrence of SEL touches/holds and their nature relate to expressed emotions and emotional climate?
- To what extent do SEL touches/holds ameliorate the intensity and nature of expressed emotions?

From the perspectives of event-oriented inquiry and interpretive inquiry there are several ways to proceed. One way would be to identify one or more SEL holds that were noteworthy in the sense of being spikes in the curve, incidents that either transformed what was happening or had the potential to do so.

An event would then be situated in a social episode by identifying an appropriate beginning and end. For example, in the Luxembourg CSSE Forum a participant began to report what happened in his group during a small group breakout. I became aware of my mounting frustration as I listened to the report and then of tension in my right forearm. The tension was created by my left hand pulling on my right arm, about six inches below my elbow. My arms were almost folded with the left over the right and the back of my right hand resting underneath the left elbow. These details

of posture were retrieved after I identified the event (the tension in my arm caused by tugging away from the right elbow), associating it with a vignette involving a colleague reporting back to a whole group in ways that frustrated me. Once the vignette was identified my next step as a researcher was to create short narratives about the conference, the small group breakout, the report back activity, and the selected vignette. Since I did not have video files to access I relied on my recollections to undertake an analysis of emotions in terms of their type, intensity, and characteristics of the emotional climate.

The analysis is highly subjective, but that is strength in that I can access thoughts and feelings that would not otherwise be available. The research is what it is, providing me with insights into ways in which an SEL hold is used in a social setting to ameliorate the intensity of an expressed "negative" emotion, thereby decreasing the possibility of an intervention that would have disrupted my colleague's report and probably would have catalyzed an unpleasant interaction. Furthermore, the analysis sets the stage for studies that examine similar holding/touching patterns relating to this SEL.

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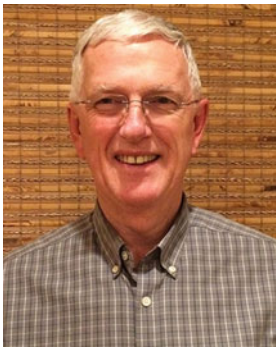

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Chapter 2
Multilectics and Its Methods

Gene Fellner

Researchers often conflate the terms methodology and method, but they are not interchangeable. A methodology is an approach to research that reflects ontological perspectives, epistemological beliefs, and axiological positions (values) that are consciously or unconsciously embedded in the researcher's research plan. Her methodology is informed by the way she sees and interprets the world; it facilitates the revelation of data that she values and represents what she believes to be the best path for constructing knowledge about her subject. In all these ways, a methodology provides a framework for the methods that will be used on the ground. Methods are tools used to construct data in the course of the research; they are infused with the ontological, epistemological and axiological foundations of the study's methodology. In this way, methodology suggests certain methods; it is a theory of method.

In this chapter I detail the methodologies and methods that inform my research in an urban middle school that serves poor African-American and Hispanic youth. I begin by explicating the methodologies that guide my work. Then, I discuss my methodology and the methods it facilitates. I continue by documenting my research in a 7th grade language arts classroom. In the context of documenting my research, I describe the methods that I have chosen to fulfill my methodology's central attributes. Intertwined with the methods of implementation are methods of representation – how I convey my research findings to others in a way that reflects the methodological values that drive the project.

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Methodology

Multilectics guides me in my educational research. It is a methodology that embraces multiplicity: multiplicity of voices (polyphony), of meanings (polysemy), of scales (multilevel) and of senses (multimodal). Multilectics also embraces the dialectical process rooted in the theories of Georg Wilhelm Friedrich Hegel and Karl Marx – the idea that social life is propelled by contradictions that presuppose each other and are in constant flux.

I choose multiplicity as a core feature of my methodology because I see knowledge as socially constructed in a world that opens itself up differently to every person depending on her position within it; knowledge is mediated by the context of the moment and by experiences that build over time. To understand what is taking place in any situation so that I can intervene successfully, I need a theory guided by these multiple ways of seeing, understanding and being in the world. The theory is necessarily founded on difference and contradiction, both mediated by experience, circumstance, and our distinctly human capability of embracing conflicting positions simultaneously.

Class, gender, and race are powerful macro level structures that mediate who we are. Though imbued with profound cultural and historical influences, they also serve the purpose of grouping individuals together on the basis of perceived similarities, masking what differentiates those within the same group and making it difficult to see beyond the stereotypes cast by the formulaic structures. This may be especially true when the structures serve the interests of the powerful, are interpreted through lenses that narrowly serve dominant goals, persist seemingly unaltered over generations, and become hegemonically anchored in thought. Within the educational domain, normative ways of interpreting data accumulated through official tools of assessment (standardized tests) reflect a narrow range of class-based ontologies and values that default to categorical prejudices; they affirm the very deficits that correlate to broad groupings of the underserved, rigidify structures of race and class that favor some populations over others, and mostly tell us what we already know about the correlation between race, class and academic achievement but provide little useful data about what is really going on in communities that underperform in schools. Standardized tests, because they define skills so narrowly, do not register the strengths, knowledges, and capacities that marginalized populations bring to the table because these are not expressed in ways that official assessment tools can measure; indeed many of these attributes cannot be measured at all. The official data, because they reflect a monophonic, monosemic, mono level approach to research, serve to strengthen the deterministic interpretation of macro level structures: According to this interpretation, if you are poor and Black or Hispanic, your future possibilities are dismal.

Though macro categories of race, class, and gender are, indeed, formidable mediators of possibility, they are only part of the story. Multilectics demands that we investigate beneath the gloss of broad categorizations and measurable data. In the field of education, multilectics proposes that in order to understand what we are studying we must view not only the grand patterns of educational achievement as

seen from a distant vantage point but also the patterns, contradictions and idiosyncrasies that are visible from other perspectives. Multilectics demands that we observe, polysemically and polyphonically, not only from the macro level but also from the meso and micro scales of activity. Multi level analysis is especially suited to reveal data that mono level investigations necessarily obscure.

Student knowledge and the unmeasurable ingredients on which knowledge rides – curiosity, passion for learning, thoughtfulness – are visible on the meso level of civil society and on the micro level of unconsciously enacted activity. Macro structures such as race, gender, and class can seem unalterable, but as they transform and are transformed by activity on other levels of social life, their seeming invulnerability to change is challenged. Hegel (1929) writes, "Consequently the Real Possibility of a case is the existing multiplicity of circumstances which are related to it" (p. 189). When we see reality in its wholeness rather than through narrow lenses, the possibilities become salient. Multilectics illuminates these possibilities.

Dialectics

Recognizing multiplicity by itself is not sufficient to provide us with a sense of what is truly going on; we need to understand the dynamic through which these multiplicities engage each other. That is why multilectics also embraces a view of dialectical change first theorized by Hegel and Marx and then developed by post-Marxist theorists. Seeing the world dialectically means perceiving a world in constant flux with every level of activity presupposing every other level and transforming it. In traditional Marxism, multiplicity was rendered dualistic, the world divided between antagonistic opposites most prominently in terms of class and class interests, the proletariat and the bourgeois, the workers and the owners of the means of production. Class categories rigidly defined men and women, and little attention was paid to internal contradictions within the categories nor to such important aspects of social life as emotions and chance. Marxist dualities, or contradictions in the form of thesis and antithesis, presupposed, confronted and transformed each other. When writing about the relationship between exchange and acquisition, Marx writes in Capital (1990),

> To say that these mutually independent and antithetical processes form an internal unity is to say also that their internal unity moves forward through external antitheses. These two processes lack internal independence because they complement each other. …There is an antithesis immanent … between private labor which must simultaneously manifest itself as directly social labour … between the conversion of things into persons and persons into things (p. 209).

Later, in Bourdieusian theory (Bourdieu 1992), for example, dualities were rejected in favor of multiplicities; different fields of social activity and nuance shaded every categorical determination. A person could be good and bad, privileged in some settings and unprivileged in others, hold conflicting allegiances simultaneously (religious, civil, governmental), belong to multiple races, classes and genders.

Emotions and chance entered the theoretical canvas, mediating historical and cultural events and bound to every act. Such ambiguity and complexity magnified the multiple circumstances enveloping any social phenomena and therefore also challenged the grip of deterministic trajectories; the possibilities for transformation became essential to dialectical thinking but without the predictive certainty that Marx envisioned. For the researcher who seeks to understand social phenomena in their fullness, the dialectical fluidity between macro, meso, and micro layers of social life and their polyphonic and polysemic interaction with one another provide data that challenge the hegemonic story.

Multilevel Observation

The macro perspective tells us about the formidable structures of class, race and gender, the categories we are born into. They reveal large patterns of social life visible from afar but little about what transpires on the level of civil society. The meso level illuminates civil society, the way we interact with one another, the artifacts we produce, the conversations we have, the emotions that dialectically interact with every human act, filtering experiences while being mediated by them. Meanwhile, on the micro level, we can observe unconsciously enacted knowledge that can teach us about how individuals and groups of individuals are thinking and feeling. The gestures we make, our facial expressions, the tone and volume of our voices as we talk all reveal data that are not easily graspable on the macro and meso levels. Unless we are in a consciously performative mode, we are mostly unaware of how we move and speak even though both mediate how and what we are learning. The psychologist Daniel Kahneman (2011) writes, "cognition is embodied; you think with your body, not only with your brain" (p. 51), and micro analysis provides data about just how the body is thinking in-the-moment. Those who witness the communication acts of others may instinctively and intuitively interpret meaning from gesture and voice, but these acts transpire so quickly that it is often not consciously absorbed and even less often remembered. Micro analysis allows us to become aware of the unaware, to witness the unconscious production of knowledge. A multilectical approach to research embraces multilevel observation, each level dialectically intertwined with the others. Paul Cezanne believed that to understand the landscape before him he had to "weld together all the partial views he could catch sight of" (Merleau-Ponty 1993, p. 67). That's what multilectics attempts to do.

Methodologies and Methods in the Classroom

Because multilectics guides my approach to research, I know that the data available from official documentation only represent a partial view of the students even though student academic trajectories are often determined by these data alone. The

data make visible only one perspective, not the multilevel observation that mediates "welding together" all of the "partial views" one can in order to understand the whole. By projecting such a curtailed view of students, the official data obscure the "multiplicity of circumstances" that allow us to evaluate student potential. Multilectics embraces a dialectical and complex view of reality. It values as a necessary approach to acquiring knowledge: (1) Seeking polysemy and polyphony; (2) Multi-level analysis: Observing the subjects of the study from macro, meso and micro perspectives in order to understand more fully; each level provides different types of data that can be used to form a picture of the whole; (3) Recognizing dialectically intertwined contradictions as central to the coherence of meaning. Each of these ingredients to a multilectical methodology suggests methods to employ on the ground. Many of these methods, in turn, incorporate multiple strategies. Each strategy is a method in itself that reflects methodological concerns.

Polysemy, Polyphony and the Method of Dialog

Dialogic methods can promote polysemy and polyphony in the classroom. Dialog – students speaking and listening to each other – is a method comprised of many methods including radical listening, reflexivity, and thoughtful higher-order questioning. All are essential to a dialog whose purpose, in the Socratic sense, is to explore the truth of one's own opinions (Arendt 2004).

Radical listening: "Making an effort to understand others' standpoints without seeking to change them" (Hayes, Steinberg, and Tobin 2010, p. xix). The dialogic act of radical listening involves placing yourself in someone else's shoes in order to see reality as they do, it means temporarily suspending your own way of looking at the world. Radical listening also necessarily advances reflexivity by guiding you to see yourself through another's eyes. Lisa Delpit (1988) writes:

> We do not really see through our eyes or hear through our ears, but through our beliefs. To put our beliefs on hold is to cease to exist as ourselves for a moment- and that is not easy. It is painful as well, because it means turning yourself inside out, giving up your own sense of who you are, and being willing to see yourself in the unflattering light of another's angry gaze. It is not easy, but it is the only way to learn what it might feel like to be someone else and the only way to start the dialogue. (p. 297)

Radical listening is a method that fosters polysemy and polyphony by creating a welcoming space for difference. It also contributes to a powerful ontological approach to being in the world. With practice, radical listening scaffolds the emergence of critical questions posed not in an attempt to persuade someone of certain beliefs but to get to the truth within the opinions of those who are engaged in the dialogic process.

Reflexivity: Critically revisiting your own thoughts and experiences is a social process. You cannot know yourself by yourself; you need others to help you to find your own truths. Even if you are only talking with yourself, you are examining your own stance through a social and collective process, yourself being informed by the

culture you are born into, the cultures you are familiar with, the people you know. Reflexivity, like radical listening, represents an ontological and epistemological way of being. Along with radical listening and as part of the dialogical method, reflexivity is deeply dialectical, founded on the idea that the collective and individual knowledge transform each other continually.

Meso and Micro Analysis in the Classroom

In addition to the statistical record that informs about class, race, gender and their correlation to academic achievement, multilectics seeks to probe beneath the statistical data to reveal a broader understanding of student knowledge. On the meso level in language arts classes, this includes studying student speech and writing, and movement. Studying student production on the meso level also calls for ways of constructing data with the potential to expose contradictions in the normative assessment of students.

Lev Vygotsky (2004) offered some insights into how to scaffold student production to reveal data about student skills excluded in the official transcripts. He commented on the subjects students are forced to write about: "These topics remained foreign to the children, they did not touch their imagination or emotions … It was a rare case that this work was linked with a goal that was understandable, interesting, and within the capacity of the children" (p. 45). In fact the Zone of Proximal Development (ZPD) could be seen as a strategy to ameliorate the alienation that many students feel towards the assignments they are given in school. ZPD suggests that if one's goal is for students to acquire academic knowledge, teachers must build upon what students already know and engage their passion. In the multi-level analysis of the case study below, I began engaging students with memoir writing because memoirs build on student expertise, invoke their passions, and welcome discussions of what they know into the classroom. Memoir writing can be seen as a method that provides meso-level data about student knowledge and experience. Many strategies scaffolded the memoir activity. These included reading model memoirs by well known authors, deconstructing those memoirs for figurative language, rich description and dialog; and prompting students to use those very elements in their writing as part of a brainstorming activity before beginning to write. All of these activities are methods used to reveal student knowledge that standardized tests do not access.

One of the core insights of the ZPD is that learning is a social process. It is mediated by culture and history, and emerges through dialog between and among responsive teachers and engaged peers. That is why, in addition to the discussions that preceded the memoir writing, teacher-student conferences, and small group and whole class discussions took place throughout the 2 months we spent working on, revising and editing the memoirs.

Video is one of the best methods of observing and analyzing student activity on the micro level. It permits the researcher to see unconsciously enacted knowledge

that is difficult and sometimes impossible to see on the meso level. Video gives access to student gestures and expressions that are integral to personal and collective meaning-making, the two dialectically engaged with each other. I use sound software (a method) to reveal the role of prosody in the construction of student knowledge. These multimodal dimensions to knowledge creation provide another "partial view" of what is going on in the classroom, one that dialectically interacts with gesture and speech to give us a picture of student knowledge, skills and potential that is not made visible by the statistical lens.

Research in a 7th Grade Language Arts Classroom

I am researching pedagogy and assessment in a 7th grade language arts classroom. A quick glance at the class and at the available statistical evidence from test assessments reveals statistical data about the macro structures that are in play: All the students are African-American and Latino/a and they all qualify for free lunch which indicates that they are poor. Of the 20 students in the class, only five (25 %) scored proficient on the state standardized language arts exam (which is to say they answered over half the questions correctly). Three of those five scored only one or two points above the score that separates proficient from not proficient. Of the 15 students who did not achieve proficiency, ten scored 20–30 points below the dividing line. Many of these students read at a third grade level. The statistical data confirm what is generally known about the correlation between poverty, race, and academic achievement in the United States. They testify to the generalized failure of Black and Hispanic students to learn academic skills crucial to compete successfully in middle class society and the perennial failure of schools to teach those skills effectively to minority youth. The statistics point to systemic and institutional failure (though one could argue that the statistical data represent an intentional outcome), but because they measure only a narrow set of skills (academic English and math abilities), they tell us little that differentiates one student from another (almost all are categorized as failures). They also tell us little about the abilities that are not being measured, the knowledges students have gained from experiences that are not validated by the tests. Furthermore, the tests tell us nothing about student desire, passion, and curiosity for learning. Many teachers, administrators and policymakers interpret the failure on the tests as indicative of a lack of these qualities rather than as part of a cycle that intensifies student alienation from academic learning by, year after year, showing them only their weaknesses. On a purely statistical level, where the personalities and non-measurable attributes of students are invisible, this deficit perspective is reinforced.

Below I present a multilectical approach to revealing the possibilities of students that challenge the statistical determinations. All the students in the vignettes analyzed below are from the 7th grade language arts class mentioned above.

Data Constructed on the Meso Level

According to the official transcripts, the writing and thinking skills of the students in this class are dismal, but the data that inform these findings are based on standardized tests designed to measure narrowly defined skills. According to these criteria, Ana (pseudonym, picture above altered) is a border-line failing student with no distinguishing characteristics. The very inclusion of her photo in this document (a method) already challenges this claim with contradictory data. We see a spark in Ana's eyes and a smile on her face that, at the very least, indicates an engagement with life that the statistical record is unable to record. We read her facial expression and, before even reflecting on the meso level, we instinctively (on the micro level) feel the human bond that connects us to her through cultural knowledge we have in common, the recognition of laughter and joy. The quantitative data that capture only her failure according to academic standards cannot represent the "textured" nature of Ana's life. Foundations for learning reside in Ana's experiences, her insights and her dispositions, not in the flat veneer the numbers portray. We are already moving away from the monosemic and monophonic image reflected in the statistics to a more multidimensional one, a key aspect of a multilectical methodology.

After reading, brainstorming and dialoging, Ana writes the first draft of her memoir:

> God in the bible
>
> One night in my kitchen with its dimmed light all you could see was the black and white stove, the off white fridge, the dusty old glass table set and what was left of the wooden cabinets. At the table Tiffany, Mi-Mi and I were sitting down talking about God. I asked Tiffany when was she going back to church? "This Sunday," she said. I asked Tiffany would she bring me a Bible. I asked a lot of questions about the bible and God. I wanted a bible so I could understand more. Tiffany and Mi-Mi were going back and forth about God and what they believed in. I interrupted them when I asked, "Is God and the bible by my side?"

> Tiffany sat up straight with her white and black sweatshirt on and told me, "God will always be by your side if you just believe." After hearing that, it got to me. I wanted to know more about God and start going to church.

The memoir, a product that emerged from a welcoming of student experience and voices (intrinsic to a multilectical methodology), mediated by the methods of modeling, brainstorming, and dialog was evidence of Ana's talent as a writer and thinker; it contradicted the official findings about her. The official records portray her only as one more example of class or racial failure because they assess her narrowly with a monosemic and undialectical gaze, rejecting her voice and her experience as epistemologically worth-less. But her memoir bristles with imagery and thought: it is descriptive of setting and of character, incorporates dialog and explores a profound question. All the prompts about literary devices that preceded the writing activity are reflected in Ana's essay demonstrating her ability, when enthused, to apply classroom lessons to her learning. The memoir goes through many different versions over a period of 6 or 7 weeks; the vocabulary becomes more specific: "There was always two kinds of noises, the noise of church was full of joy and inspiration. At home was just ruckus. The sound of me picturing myself in church full of joy calms me down." The spelling and grammar also improve as we work on the memoir together, but sometimes it is difficult to know if the vernacular writing should be "corrected." On classroom and standardized tests, points could be deducted for her use of "was" instead of "were" or her lack of a subject pronoun in her second sentence, but meaning is in no way compromised and Academic English might hinder the integrity and the vividness of her voice. Furthermore, for Ana, the language she uses functions well for her at home and with her friends whereas she has relatively little experience with any other language context. This is a conundrum that doesn't face students whose vernacular is closely aligned with dominant English. Multilectics recognizes that polyphony is vital to research integrity as well as to learning in the classroom; in that regard her grammatical "errors" are not the most important aspect of her writing production. From a multilectical standpoint, if we want to know about Ana, we need to let her speak for herself; her memoir opens this path for her. She is proud of what she has written and she reads her story before the entire class. Her memoir addresses Vygotsky's observation that students will perform better when an assignment speaks to them. The memoir also allows Ana to see herself in her writing and thus increases the value of learning to write well.

Data Constructed on the Micro/Meso Level

The memoir activity provided meso-level data about Ana's abilities that the official statistics did not reveal. It also encouraged Ana to continue to share more of her writing. I know this because shortly after Ana had written her memoir, she asked me if I would read a poem that she wrote. The poem was not a response to a school assignment but a response to an event in her life, a love affair that ended badly. Ana is 12 years old and she is struggling to find words that will help her make sense of a

relationship that left her wounded. She is using writing to help her cope with and reflect on her life, a use of writing many great authors subscribe to. The official transcripts do not note Ana's motivation to use language fruitfully or the fact that she writes for herself on her own time, but on the meso level of social engagement, these building blocks of academic learning come to light.

Ana comes to me with her poem because from our work together on her memoir she believes she can trust me. She knows I will encourage her, be on her side, take her writing seriously, not judge her lifestyle, and learn from her. She knows this because the dialogic process that surrounded her memoir writing incorporated radical listening and reflexivity. We could think of trust as fundamental to methodologies and methods that facilitate polysemy and polyphony, the pavement that allows a two-way street to run smoothly. Ana choosing to discuss her poem with me is in itself meaningful information; it contradicts her often hostile attitude towards school and teachers. At one point during the group discussion of her poem she says to me, "If we were talking about stuff like this in class … I'd be ready to come to school. I mean when I be coming into the school building, it's like 'Oh God, do I really have to come to school?'"

I suggest to Ana that we get together a group of her peers and discuss the poem together. I believe that human beings construct meaning together through dialog. Ana will get to know herself and the meaning of her own words more profoundly with the help of the group just as the individuals in the group will learn about themselves and each other through the dialogic process. Ana invites two of her friends, Sheryl and Maleeka to join us for the discussion. As we begin to talk, Darryl and Kelvin, who have been thrown out of their science class for being disruptive, join us as well. Of the five students in the group, only one scored comfortably within the proficient range on the standardized tests. Two of them scored well below proficient and two, including Ana, barely achieved proficiency (Ana by one point).

With the permission of the group, I video record our discussion. Video is a method designed to illuminate activity on the meso and micro levels of social life. It is part of my multilevel methodology, part of my ontological stance that in order to effectively understand what is going on we must view phenomena from as many vantage points as possible. The micro level of analysis reveals unconscious enactments of knowledge that are difficult to capture in the moment; video makes it possible to retrieve and study events after they have taken place (though analyzing an event retrospectively unavoidably alters interpretation).

I have selected two vignettes from the 50-min discussion about Ana's poem. Because I believe that methods of representation should, when possible, reflect the methodologies and methods that inform the study itself, I have used multiple graphic strategies to convey the multiple dimensions of the data that emerged from our conversation. The written transcripts tell us the words that were spoken and the length of the silences (in seconds within parentheses) that nuance the words and carry meaning themselves. The images of facial expressions and body language tell us about how meaning is constructed on both conscious and unconscious levels. These physical movements and positions reflect the individual|collective

dialectic (the vertical line indicates a dialectical relationship) which is integral to the communicative act. They visually convey data about group solidarity and lack of solidarity, and they give us a window into how knowledge moves cascadingly through the group. In this way, the graphic form well illustrates Mikhail Bakhtin's (1986) theory that every utterance is just a link in a chain of utterances and Bakhtin's insistence that the listener, through even his unspoken responses, mediates what the speaker is saying. Voice, its frequency, volume, and rhythm also contribute to the group endeavor and making sense of Ana's poem. Voice conveys excitement, intimacy, thoughtfulness, hesitancy, sadness and joy. It emerges with words and bodily gesture. My multilectical epistemology holds that voice, like gesture, reveals a dimension of knowledge that can inform us about what is going on in any social situation. In electronic documents, sound files can be included in written documents but in books this is not yet possible. Here I represent higher volume by increasing the point size of the words within speech bubbles, and I represent overlapping speech by its inclusion within the same speech bubble. It is one more representational method of trying to convey the multidimensional/multimodal aspects of social interaction that are key to my methodology. Because this book is printed in black and white, the use of color to represent emotions and to distinguish speakers is not visible; you can refer to the online version of this chapter to see how color is used in representing events.

Vignette 1: When Gestures and Words Tell Different Stories (9.5 seconds)

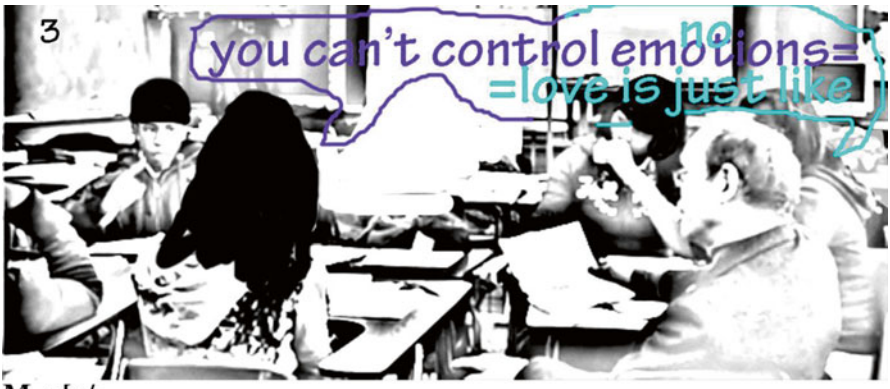
A few words about transcription notation:

M. n[o/:	Brackets indicate where overlapping speech begins and ends.
	/: The slash indicates where one person's overlapping speech ends. In the first two lines at the left, the "o" of "no" and the word "you" are spoken at the same time.
S: <you] can't control emotions=	<: The sideways caret symbol indicates where the overlapping speech of the 2nd person begins.
M: =love is just like	=: The equal symbol indicates no pause between speakers. In this case, the word "love" immediately follows the words "emotions."
(.9)	Numbers between parenthesis indicate pause in speech in seconds. In the case at the left, the pause lasted nine-tenths of a second.

Ana reads her poem about love to the group. It is filled with metaphoric phrases: "love will be thick and thin," "love is like roses," "love feels like death." The outtakes below document the initial 9.5 seconds of the conversation that emerged from my question to Ana, "You write, 'but can love be hate or madness, love is what you want it to be.' So can you control what love is?" An analysis will follow the graphic representation of the conversation.

G: So can you control what love is?

(.7)



M. n[o/
S: <you] can't control emotions=
M: =love is just like

G: You {can't control/ =
M: <it's like]
K: <Yes you COULD]

A: You gonna control [YOUR
K: <IF you think about
S: <???
M: <???

A: emotions but not your lover's emotions/
K: you can hold it in because I always do that]

D: ????

Analysis Vignette 1

G: So can you control what love is?

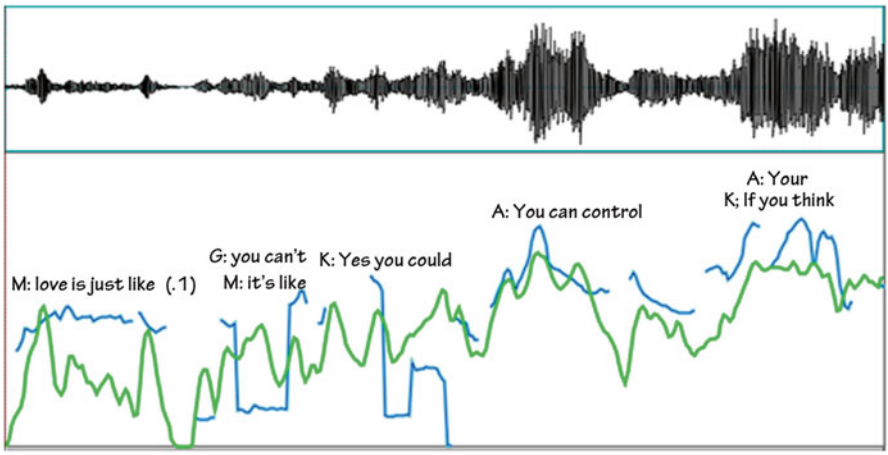
(.7)

The entrance of another teacher as I finished asking my question causes a brief distraction, which accounts for the temporary glance of Kelvin to his right (#1). More significant is the long pause of almost a second that follows my question, "so

can you control what love is?" (#2). "Pauses are opportunities… for anyone to take the conversational floor" (Roth 2006, p. 243) and a half -second pause generally invites a change in speakers (Tobin 2005). Here the pause lasts just over a half second. During that silence, Ana does not change her position or make eye-contact with anyone; her left hand, loosely fisted, covers her mouth. Roland Barthes writes, "silence speaks," (1985), and here we can feel in the pause the gravity of the question asked and the seriousness with which all participants regard it.

M. n[o/
S: <you] can't control emotions=
M: =love is just like

Though Ana remains in her pensive state, two of her colleagues enter the conversation in quick succession (#3). Maleeka says "no," and, before she's finished Shelly elaborates, "you can't control emotions." Shelly's entrance into the conversation is less an interruption than a supportive addition to Maleeka's statement and a rationale for it. With barely a pause (.1 seconds) Maleeka then begins to add her own explanation, "love is just like…" Her speech is rapid, excited – we can witness, constructed in the moment, the "links" that Bakhtin writes about. The group collectively grapples with the question I posed. Kelvin, who was distracted just a second ago, is now totally focused on the conversation; he makes eye contact with me. It appears as if he's getting ready to contribute to the conversation as well.



G: You {can't control/ =
M: <it's like]
K: <Yes you COULD]

I interrupt Maleeka (#4) by questioning Shelly's response, "you can't control emotions?" As soon as the word "can't" escapes my mouth, however, Maleeka, still continuing her thought, says, "It's like...." Before she finishes Kelvin, louder than everyone else, insists, "yes, you could." There is no pause during these interchanges at all, as if we are listening and responding to each other simultaneously. Though Ana hasn't moved from her pensive position, the voice of every student who speaks is louder and at a higher frequency than the previous contribution (see chart above), manifesting a passion about the subject and an urgency to be heard (green represents volume, blue represents frequency). At this moment there is a great deal of passion and engagement but not so much radical listening.

A: You gonna control [YOUR
K: <IF you think about
S: <???
M: <???

Suddenly Ana, who has been sitting almost immobile since I first asked the question about controlling love, explodes into the conversation (#5). Clearly, her silence has not been inattentive; she has absorbed the conversation around her and listened intently. Her voice now rising above everyone else's, she declares emphatically, "You can control your emotions." Darryl says something, but he is far from the camera and his words cannot be deciphered from the video. Kelvin, not to be drowned out, raises his voice (unconsciously) to match the volume of Ana's voice.

In the moment, involved in conversation, it is almost impossible to be cognizant of (much less remember after the fact) the steadily rising decibel level (green line) and pitch (blue line) of speakers as they contribute their insights. The sound file of the session, extracted from the video, makes it possible to actually see this trend and

measure, if we want to, the precise rise in pitch and energy level of the voices. For my purposes here, it is sufficient to illuminate the pattern of *unconsciously* enacted speech that is passionate and experience-laden. In the context of an argument or as part of conversation in which negative emotions are present, such escalations in voice could heighten the tension. Here tension escalates, but it does so within a context of a collective need to make sense of the questions posed by Ana's poem and highlighted by me. Involved as we are in a common task, the tension is characterized by an urgency of all group participants to understand if emotions can be controlled.

Another insight that the video provides is that of gestural significance in meaning making. Ana emphatically emphasizes the words "you" and "your" as she says, "YOU can control YOUR emotions," but her hands, equally emphatic, are saying, "I can control MY emotions." They point inwards towards herself, the fingers of her right hand poking six times against her chest to emphasize, repeatedly, the personal nature of the knowledge she is sharing. There is a contradiction between her spoken and gestural language here, an effort to reconcile the general *you* with the specific *me*. The rise in her voice combined with the contradiction between words and gestures betray the confidence with which she announces her opinion. For Ana, this is all happening on the unconscious level; the rest of us may instinctively read the contradiction and its meaning (we know Ana is describing a personal wound) but not until we see the video can we understand the elements that made the contradiction manifest. Because Ana's voice is so dominant right now, the other participants in the group may not even have noticed her six strongly self-referential gestures taking place within one second; I had no recollection of them. Susan Goldin-Meadow (2003) demonstrates that when a person's gestures and speech contradict each other in the process of seeking a solution to a mathematical equation (a correct and an incorrect solution), it is a sign that she is, unconsciously, entertaining more than one possibility for solving a problem. According to her research, students who display such a gestural-verbal "mismatch" indicated a greater "readiness to learn" and to "profit from new input" (p. 47) than those who didn't manifest contradictory concepts in speech and gesture. That lack of synchrony, then, between conscious and unconscious thought may alert the teacher to a student's ZPD. A teacher who observes the contradiction between gesture and speech can then help a student decipher the thinking process of which that student is herself unaware. In my study I interpret the contradictory speech and gestures of Ana as indicative of uncertainty and possibility, an opportunity to reveal Ana's thinking to her and thus advance her self-knowledge and help her unravel her thoughts.

In terms of representational methods I have coated both Kelvin and Ana in red (see electronic version) to convey the passion with which they are speaking. For the same reason, I have enlarged the type point size of their utterance. The speech bubble incorporates the words of the four students who are speaking simultaneously, each one invested in the conversation. Finally, I have included graphic representations of pitch, decibel level and composite sound wave within the cartoon in an attempt to viscerally convey the passion of the moment. A statistical chart of decibel levels and frequency rates would give us cold data but lack the sense of

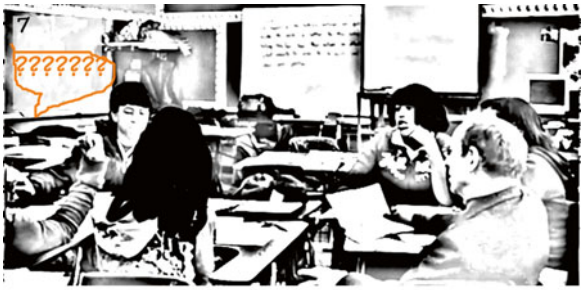
unmeasurable excitement which we are collectively experiencing in the moment, an experience that characterizes formal education at its best. In line with multilevel analysis and an artistic/multilectical methodology, my representational methods strive to embrace "emotional" as well as "intellectual" knowledge, the two being dialectically related.

A: emotions but not your lover's emotions/
K: you can hold it in because I always do that]

Ana's previous contradictory verbal-gestural performance is now transformed into what David McNeil calls "synchronous and co-expressive" but "not redundant" (2005, p. 91) communication. With her next phrase (#6), her words and gestures reinforce each other rather than contradict each other; the gestures don't merely repeat the sense of the words but elaborate upon them, providing a metaphoric image that gives you more information than the words by themselves express. As Ana says that you can't control "your lover's emotions," the index finger of her right hand stabs the desk to her right, with each consecutive stab a bit further away from her body demonstrating, visually, the growing distance between her and her lover as their relationship began to dissolve. Meanwhile, her right hand stays still, inclined inward towards her, to represent the steady place from which her lover is increasingly distant. One hand represents her, the other her lover, and with each word of her phrase the two are moving farther apart. Had I noticed the gestural language in the moment, or while I was still working with Ana, I could have showed her the two different but related messages she was conveying. The first that she conveys verbally, "You can't control your lover's emotions," and the second reflective narrative that she communicates gesturally, "He's moving further and further away from me and I can't do anything about it." The radical listener not only understands the information that Ana is sharing with us but also the emotional knowledge that she is feeling loss and powerlessness. The only contradiction that remains is that she is still using the word "you" to refer to herself. Once she has completed her thought, both hands go to a resting and neutral position and her lips relax (see outtake #7 below). All this is happening on the micro unconscious level though we can see it on the videotape. The gestural information tells us about a non-verbally articulated aspect of Ana's thinking process and the emotional turmoil that her words, by

themselves, do not do. The gesture-speech contradictions and the visual metaphors that her hands convey provide information that the attentive teacher can employ to help Ana probe her own thinking.

Meanwhile Kelvin also personalizes the conversation, contributing information from his own experience and knowledge of self. He says, in agreement with Ana's words, "if you think about it, you can hold it in [emotions], because I always do that." Where previously his body was relaxed, it is now tense, raised, and aimed towards the center of the circle, his head jutting adamantly forward. His body and his voice, clear and loud, transmit the same message of confidence.



Darryl says something (#7) but, again, his voice is muffled on the recording. Ana, having finished her thought, is in a position of rest. Kelvin is still inclined forward and ready to speak. In a half a second he will say, "Because I always do that [hold in emotions] because I don't like crying in front of people." Just as Ana has made herself vulnerable by speaking of a recent breakup, Kelvin now makes himself vulnerable by admitting he sometimes is on the verge of tears. That they are both willing to personalize Ana's text demonstrates the safety they feel within this group. They are making the type of text-to-self connections (the text being Ana's poem) that teachers are told to teach students how to do. But this vignette shows that students don't always have to be drilled in the text-to-self strategy. With Ana's poem, they made the connections effortlessly.

Vignette 2: When Gestures Signal Insight and Solidarity (5 seconds)

Ana has written in her poem that "love can be hate or madness," and so I ask her if you can love and hate someone at the same time. The response to my question is immediate:

A: Yeah=
K: =No=
S: =Yeah

S: Yes, your mother

(.8)

A: Yeah, cause I ah

A: love my mother, but sometimes I be hating her

Analysis Vignette 2

A: Yeah=
K: =No=
S: =Yeah

S: Yes, your mother

I have asked Ana a question ("can you love someone and hate them at the same time") (#8) to which she immediately responds with a "Yeah." Darryl also immediately responds in the affirmative while Kelvin disagrees.

Shelly, who did not jump in immediately now enters the fray with a strong gesture to accompany her statement "Yes, your mother" (#9). Her right arm, at the side of her body, is bent at the elbow and her right hand is palm up in what is a culturally recognizable gesture that signifies "isn't it obvious?" when accompanied with her emphatic speech. Her exclamatory phrase rises 63 Hz as she says the word "your," and rests at a frequency that is midpoint between her highest pitch and her starting pitch. As she speaks and gestures, she is providing a concrete example that gives credence to Ana's "Yeah," an example that all the students can relate to.

(.8)

There is a pause of .8 seconds (#10) in which everyone focuses on Shelly who maintains her adamant gesture. The length of the pause (a .5 seconds pause generally invites a change of speakers), combined with the collective focus on Shelly's gesture transforms this moment into a shared and epiphanic experience as the group processes Shelly's astute synchronous verbal/gestural/tonal answer to the question.

A: Yeah, cause I ah

Ana, in solidarity with Shelly and pleased to have her own thoughts deciphered, smiles broadly as she unconsciously mirrors Shelly's gesture, makes eye contact with Shelly, and verbally confirms Shelly's insight by using her own mother as an example of someone she sometimes loves and hates at the same time (#11). It is an example of Vygotsky's observation that meaning is socially constructed, Bakhtin's perception that speaker and listener are equal partners in the collective making of meaning, and McNeill's belief that thought, speech and gesture are all dialectically intertwined. Even without dialog, the image of these two 12-years olds in mirrored poses demonstrates their in-the-moment making-sense-together of the contradictory notion of love and hate being joined together.

A: love my mother, but sometimes I be hating her

Shelly, having shared her insight with the group, now rests her hand on her lap. Ana, however, keeps Shelly's contribution alive by maintaining her mirrored gesture (#12). She turns her attention to me, the teacher, and sums up what she has learned, "I love my mother but sometimes I be hating her." Her speech reflects the vernacular of her community and adheres to perfectly consistent grammatical rules (Gee 1996) though her use of the infinitive verb form would be graded as not conforming to academic English rules. Her left hand, palm down, moves steadily towards her supine right hand. One hand palm up, the other palm down; one hand fixed, the other in motion all within the same horizontal plane as they reflect the very contradictions of the love-hate contradiction that dialectically form a coherent whole.

Concluding Thoughts

Year after year, despite school "reform" movements and the political outcry about failing schools, the official picture of student failure in underserved African-American and Hispanic communities remains largely unchanged. I posit here that this failure endures because of the monosemic and monophonic lenses through which policymakers evaluate the students they are authorized to serve. If you only value hegemonic language; if the voices, experiences, and emotions of students are seen as peripheral building blocks to academic learning because they stray far from what is considered mainstream; and if you believe that the standardized tests are able to quantify student intelligence and potential, then the pedagogy you employ will continue to exclude large swaths of students.

I offer another way, a multilectical way. Though the educational system won't be fundamentally altered until racism and classism are substantially diminished, perturbations on meso and micro levels have the power to transform macro structures through exciting individual and collective agency. That's because every level of social life is dialectically engaged with every other level; if students see that the possibilities for transcending the obstacles they face are worth their while, then macro structures will be increasingly vulnerable. Some of this transformative work can take place in the classroom.

My research suggests that if you welcome student voices and experiences into the classroom, you will multiply the possibilities that they will value what school has to offer and feel less alienated from academic culture. And so, Ana's memoir served as a vehicle for grammar lessons, an entry into discussing academic English vs. the vernacular, and a scaffold for sharing more writing with teachers and peers. The poetry discussion excerpted in this study also led to other writing activities involving other failing and barely-proficient students and to the creation of a weekly poetry club in which students, through poetry, discuss their lives and how to best represent those lives in text. None of this activity is reflected in test scores, but it is the excitement and the motivation that surges below these after-school sessions that policymakers, teachers, and administrators can learn from and build upon. If they continue to judge only on the basis of the tests, than schools will maintain their distinction of suppressing the enthusiasm, hope, and drive to learn of many of their students. If they neglect meso and micro dimensions of student engagement with academic learning because many of these are unmeasurable, then schools will subordinate the thrill to the chore of learning, contradicting the oft-repeated goal of creating life long learners.

My research also demonstrates that by analysing student production on the meso and micro levels, data that are hidden to the macro perspective get illuminated. In the vignettes shown in this chapter, the gestural language of students provides information about their thinking processes and their emotional states that their words by themselves fail to do. The mismatches between speech and gesture, and the visual and metaphorical dimension that gesture often contributes to speech, can serve as an entry into higher-order thinking. Micro and meso level analyses need to be seen as

equal partners with macro level analysis to help us to understand what is going on with the students in our classrooms. The way in which thought, speech, gesture and voice interact with each other, and the way they relate to race, class and gender, is an area of research that demands further attention.

Wolff-Michael Roth and Michiel van Eijck (2010) write about teaching to enhance the "fullness of life." A multilectical approach to research, teaching and learning, because it values multidimensionality, has the potential to promote the fullness and the complexity of students' lives. Multilectics doesn't ignore the statistically recorded obstacles and deficits that students from poor neighborhoods face, but it shows those to be only a part of the story. My multilectical research illuminates strengths of failing and almost failing students and implicitly shines the light on the terrible cost to society of not encouraging those strengths through methods infused with multilectical approaches to teaching and learning.

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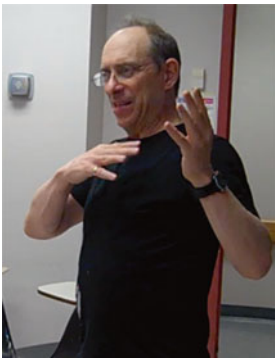

Gene Fellner In 2014, I became an Assistant Professor of Education at the College of Staten Island, part of the City University of New York, after having spent many years as an artist and activist. My research thus far has been mostly inspired by my work as a mentor to Language Arts teachers in some of the most underperforming schools in Newark, New Jersey. My investigations seek to expose the multidimensionality, intelligence and vitality of students who are represented as statistical failures in the official record. Methodologically, I explore the spaces where art and research meet and seek to develop ways of thinking that illuminate and hopefully advance the many strengths of underserved students. I also participate in research with secondary school students, teachers and administrators both in special and general education contexts.

Chapter 3
Heuristics for Mindfulness in Education and Beyond

Malgorzata Powietrzynska

"Teaching Should Not Make You Sick"

In our research conducted in a graduate science education course, we discovered that often when students cotaught classes, their heart rates and oxygenation of the blood reached dangerous levels (Alexakos and Tobin forthcoming). We considered these physiological markers as manifestations of heightened emotional states associated with teaching. Many of the study participants were unaware of the impact of emotions on their physiology and expressed a profound surprise when faced with this realization. Jonathan Turner (2002) and Randall Collins (2004), who argue the primacy of emotions in human interaction, confirm that much of what happens in social life happens without conscious awareness. We are often unaware and inattentive to the moment-to-moment emotional states that accompany our experiences. If sustained and not regulated for extended periods of time, negative emotions may inevitably lead to poor health. Richard Davidson, a leading scholar of affective neuroscience, provides evidence that human emotions may be the most powerful influence on our physical health (Davidson and Begley 2012). In the field of education, a potential result is a well-documented high teacher turnover as reported by Richard Ingersoll and David Perda (2010) as well as absenteeism among students such as that described in the study by Kenneth Tobin, Gale Seiler, and Edward Walls (1999).

Since we believe that teaching should not put in jeopardy the health of teachers or students, we undertook research promoting self-awareness of emotional states. Our research was conducted with 19 pre-service and in-service science teachers of

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diverse cultural, ethnic, and racial backgrounds at a large, urban, public college in the Northeast. I was among the group of Ph.D. students invited to collaborate on this project by the principal investigators Kenneth Tobin (my advisor) and Konstantinos Alexakos (the class instructor). Our aim was to develop interventions that would allow teachers (and students) to monitor their emotions, to counteract their negative impact and to maintain wellbeing. We are among a growing number of educators who believe that mindfulness, through raising awareness, may be a powerful tool in shaping our emotional states. We decided to introduce mindfulness into the class through the use of a *heuristic*, which we refer to as a *low-grade intervention*. A low-grade intervention relates to a construct illustrated in the heuristic by a set of characteristics, which are salient to the contexts in which the construct is applicable. In this chapter, I discuss our approach to theorizing, developing and applying a mindfulness heuristic. The roles of reflexivity, contingency, and interpretive inquiry, all essential to our methodology, are emphasized.

Introducing Mindfulness Reflexively

A multi-faceted, subtle and somewhat elusive construct, mindfulness may be challenging to explain. One analogy to how our minds work is that of a DVD player. We often find ourselves in a fast-forward (thinking about the future) or rewind (focusing on the past) mode rather than being in the moment. In other words, we experience what is often referred to as *mind wandering*. Amishi Jha (2012) points out that while mind wandering may have some benefits, it is associated with difficulties performing current tasks. The trick is to be able to focus our mind on the present experience and that is where mindfulness may be of assistance. Jon Kabat-Zinn (1994), a leading mindfulness scholar, defines mindfulness as paying attention in a particular way: on purpose, in the present moment, and non-judgmentally. Since there is growing interest in secular applications of mindfulness, Scott Bishop and his colleagues (2004) convened a panel of researchers who reached consensus on the various components of the construct and developed its operational definition. The focus was on providing greater precision and specificity of the construct and on facilitating its measurement development and hypothesis testing. The group proposed a two-component model of mindfulness. The first component involves self-regulation of attention so that it is maintained on immediate experience, thereby allowing for increased recognition of mental events in the present movement. The second component involves adopting a particular orientation toward one's experiences in the present moment, an orientation characterized by curiosity, openness, and acceptance. Kabat-Zinn (2003) refers to this second component as "an affectionate, compassionate quality within the attending, a sense of openhearted friendly presence and interest" (p. 145). To Gordon Marlatt and Jean Kristeller (1999), mindfulness involves observing one's experiences "with an attitude of acceptance and loving kindness" (p. 70). According to Sue Kraus and Sharon Sears (2008), "one metaphor for mindfulness is a bird, with one wing of

awareness and the other wing of compassion" (p. 170). Unless awareness and compassion are in balance, the bird of mindfulness cannot fly.

Awareness and acceptance rather than avoidance and suppression may prove effective in alleviating negative emotions. For example, Turner (2002) finds that defense mechanisms to mitigate the effects of negative emotions such as repression, defensive attribution, projection, and displacement are counterproductive to the smooth flow of an interaction. Instead, says Turner, "if individuals are successful in overcoming their pain, they will typically experience pride that can work to tear down the defense regime" (p. 91). We maintain that one way to overcome pain is through being mindful of one's emotions. Through mindfulness meditation, one may practice observing thoughts, feelings, and sensations moment by moment and nonjudgmentally, viewing them simply as they are: thoughts, feelings, sensations, nothing more and nothing less.

A relationship between emotions and conduct is a big part of mindfulness. Although it may be difficult to do, the idea is to recognize emotions as they present themselves, name them, and let them go. If emotions are stuck to conduct then agency may be used to separate them. Usually examples are given concerning anger in its low-grade forms that express frustration. Consider Rey Llena, a teacher-researcher in many of Tobin's studies on emotions and author of the opening quote to this chapter. In Rey Llena's case the strident anger he exhibited as he taught continued to be expressed hours, days, and weeks later (Tobin and Llena 2012). It was like the social resonance that occurs when structures similar to those associated with the initial expression of anger reappear. Structures that serve as sites for resonance might include the same person or persons associated with the initial event in which the emotions were generated, a friend of that person or those persons, a similar prosodic pattern, and even the same classroom. Rey's sustained inability or perhaps his unwillingness to regulate his emotional states had serious negative implications for his physical health.

The Hermeneutics of Mindfulness

A major feature of our mindfulness heuristic was reflexivity, or becoming aware of the unaware (Bourdieu and Wacquant 1992). We theorized that once research participants (or students in the classroom) became aware of the different characteristics in the heuristic, we would witness evidence of awareness about mindfulness in their language and practices. We believed that encouraging greater mindfulness among teachers and students would assist them in regulating emotions that accompany teaching and learning. The respondents commented that the heuristic made them think and internalize their feelings; made them stop and think more and be more reflective than they usually were; made them think of things they never thought about; made them think about themselves. Thus, it was evident that the heuristic successfully mediated reflexivity since it actually worked as an enhancer of self-awareness.

There was a history to our use of heuristics. Over a decade earlier, during his close collaboration with Wolff-Michael Roth, Tobin developed and used heuristics as pedagogical tools with pre-service teachers in the Teacher Education Program at the University of Pennsylvania and with inner city school students in Philadelphia. Examples of heuristics that he developed at the time include *Heuristics for Productive Coteaching* and *Heuristics for Productive Cogenerative Dialogue* (Roth and Tobin 2002). The heuristics were generated by closely examining videotapes of coteaching involving new teachers, supervisors, and researchers. The heuristic characteristics were meant to capture practices that occurred during effective coteaching (such as *willingness to step back* and *tolerance of others' actions*) and could be used for planning and enacting such practices.

The development of a heuristic for mindfulness built on Tobin's earlier work. Tobin would also play a pivotal role in our efforts of theorizing the construct. To make the heuristic meaningful, our approach to developing the heuristic was collaborative, polysemic (involving multiple-meanings) and polyphonic (multiple-voiced). The major contributors to the development of the heuristic were the pre-service and in-service teachers who participated in our study at the time. We also extended an invitation to collaborate on the mindfulness project to scholars who worked at universities in the US and in different parts of the world. From the very onset of our study, we envisioned it to have a global reach and to become an international study that examined mindfulness in a variety of different contexts related to science education. Hence, we foresaw working with colleagues to develop contextually relevant heuristics. Many of the contributors embraced the idea as evidenced in the following comment:

> I find your work on mindfulness most interesting and it relates well to some of my own reading of the crucial role of emotion in maintaining attention – a necessary prerequisite for any learning. Mindfulness, then, relates to awareness of emotions and focusing on it could be useful for students and classroom teachers in 'accessing' emotions of their own and their students to facilitate learning.

Because yoga practitioners deal with mindfulness much of the time, we considered it important for our study to involve people in our professional and personal networks who practiced yoga. Also, because these individuals understand mindfulness in ways that are probably deeper than those of other people, they might be able to provide input that would broaden the construct.

In order to engage these different voices in the conversation about mindfulness and heuristics, we utilized on-line resources including the SurveyMonkey® and email communication. We also discussed the heuristic in the graduate classes where we conducted our study as well as during research squad meetings and larger gatherings such as monthly USER-S (Urban Science Education Research Seminars) forums. Established by Tobin in 2004, USER-S provided an ideal platform for exchange of ideas in the research community.

First Iteration of the Heuristic

Since Tobin asked me to take the lead on the development of the heuristic, my first instinct was to review the extant literature. Knowing that in its format our heuristic would resemble a survey, I identified several mindfulness-related scales whose reliability and validity evidence appeared to have been well established through multiple studies. In my search for the broadest construct possible as a starting point, I chose to focus on two surveys: the Five-Facet Mindfulness Questionnaire or FFMQ (developed by Ruth Baer, Gregory Smith, Jaclyn Hopkins, Jennifer Krietemeyer, and Leslie Toney (2006)) and the two-factor trait version of the Toronto Mindfulness Scale or TMS (as proposed by Karen Davis, Mark Lau, and David Cairns (2009)). When combined, the two scales offered seven facets of mindfulness: observing, describing, acting with awareness, non-judging, non-reacting, curiosity and de-centering (see Table 3.1 for definitions of the seven facets as offered by Ruth Baer, Erin Walsh, and Emily Lykins (2009)).

Table 3.1 Meanings of seven facets of mindfulness

Mindfulness facet	Relevant scale	Meaning of the facet	Example of a characteristic as used in our Heuristic
Observing	FFMQ	Includes noticing or attending to internal and external stimuli, such as sensations, emotions, cognitions, smells, sounds, and sights	12. I pay attention to sensations, such as the wind in my hair or sun on my face
Describing	FFMQ	Refers to labeling observed experiences with words	2. I'm good at finding words to describe my feelings
Acting with awareness	FFMQ	Includes attending to the activities of the moment and can be contrasted with automatic pilot, or behaving mechanically, without awareness of one's actions	3. When I do things, my mind wanders off and I'm easily distracted
Non-judging of inner experience	FFMQ	Refers to taking a non-evaluative stance toward cognitions and emotions	4. I criticize myself for having irrational or inappropriate emotions
Non-reactivity to inner experience	FFMQ	Is the tendency to allow thoughts and feelings to come and go, without getting carried away by them or caught up in them	5. I perceive my feelings and emotions without having to react to them
Curiosity	TMS	Reflects interest and curiosity about inner experiences	7. I am curious to see what my mind is up to from moment to moment
De-centering	TMS	Emphasizes awareness of experiences without identifying with them or being carried away by them	33. I am aware of my thoughts and feelings without overidentifying with them

Typically, in contemplative-related psychology literature, scales, questionnaires or surveys are developed, validated and utilized to provide self-reported measurement of mindfulness pre- and post-intervention. The idea is to empirically demonstrate the effectiveness of the treatment in raising levels of mindfulness. For example, James Carmody and Ruth Baer (2008) demonstrated significant increases of scores as measured by the FFMQ administered to individuals before and after they completed the MBSR (Mindfulness-Based Stress Reduction) program. In light that our heuristic was meant to act as an intervention in its own right, our major concern was not with using it to document the pre/post-treatment difference. Establishing causality (the direct effect of the intervention) was not central to our hermeneutically driven research and we were not focused on measuring the levels of mindfulness or on developing an all-encompassing definition of it. Instead we saw our heuristic as generative in the sense that once a person read the characteristics and responded to them, the characteristics became objects for reflection and changes in practice. In other words, completing the heuristic would provide a context for reflexive changes.

Having selected 5 characteristics for each mindfulness facet, we generated a 35-characteristic multidimensional instrument complete with a 5-point Likert scale (see Fig. 3.1). We were interested not only in the relationship between how people rated themselves vis-à-vis mindfulness but also in their concepts of spirituality, meditation and emotions. Additionally, in our hermeneutic approach, it was essential to allow for comments regarding the experience with the heuristic. Consequently, relevant open-ended questions were added.

Even though the resultant instrument looked like a survey, its different purpose made it something radically distinct. The inclusion of a rating scale with each characteristic is meant to assist in creating a personal bond between each individual and a particular mindfulness characteristic. A respondent thinks briefly about each characteristic in relation to his/her own conduct and chooses a point on the rating scale to represent the extent to which he/she enacts that characteristic. It may be of little significance whether the selected point is an accurate reflection of how the person actually conducts social life. As long as the description of the characteristics and the associated rating scale assists in creating a personal bond, the objective has been met. As a person subsequently enacts social life, it is possible that this characteristic frames what is happening. In other words, associated interactions that are salient to this characteristic might be undertaken with greater awareness of the phenomenological *what happens* and the hermeneutic *why it happens*. We are not arguing that this occurs in a deterministic way but rather that heightened awareness about (in this case) the construct of mindfulness in terms of a diverse set of characteristics is an affordance for making sense of social life through mindfulness.

1. When I'm walking, I deliberately notice the sensations of my body moving.
2. I'm good at finding words to describe my feelings.
3. I do not allow myself to get distracted from the task at hand.
4. I don't criticize myself for having irrational or inappropriate emotions.
5. I perceive my feelings and emotions without having to react to them.
6. I have a hard time separating myself from my thoughts and feelings.
7. I am not curious to see what my mind is up to from moment to moment.
8. It is hard for me to put my beliefs, opinions, and expectations into words.
9. I do not feel the need to judge how I feel.
10. I seek to control unpleasant thoughts and feelings.
11. When I have distressing thoughts or images, they tend to consume me.
12. I rarely notice the wind in my hair or sun on my face.
13. I focus consciously on everything I do.
14. I am not curious about my thoughts and feelings as they occur.
15. When I'm terribly upset, no words can describe how I feel.
16. I make judgments about whether my thoughts are good or bad.
17. In difficult situations, I can pause without immediately reacting.
18. I remain curious about the nature of my experiences as they arise.
19. I am more invested in just watching my experiences as they arise, than in figuring out what they could mean.
20. I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing.
21. My natural tendency is to put my experiences into words.
22. I rush through activities without being really attentive to them.
23. I approach my experiences by trying to accept them, no matter whether they are pleasant or unpleasant.
24. I am curious about my reactions to things.
25. I notice the smells and aromas of things.
26. I do jobs or tasks automatically without being aware of what I'm doing.
27. I am curious about what I might learn about myself by just taking notice of what my attention gets drawn to.
28. I think some of my emotions are bad or inappropriate and I shouldn't feel them.
29. I tend to react strongly to distressing thoughts and/or images.
30. When I have distressing thoughts or images, I judge myself as good or bad, depending what the thought/image is about.
31. I have trouble noticing visual elements in art or nature, such as colors, shapes, textures, or patterns of light and shadow.
32. I can usually describe how I feel at the moment in considerable detail.
33. I am aware of my thoughts and feelings without over-identifying with them.
34. I find myself doing things without paying attention.
35. When I have distressing thoughts or images, I just notice them and let them go.

Fig. 3.1 Characteristics in the first iteration of the mindfulness heuristic

Emerging Patterns

Along with our collaborators, we quickly identified areas where the heuristic needed improvements. Many respondents were distracted by what seemed like repetition. This was particularly true for characteristics sharing the same stem as in #11, 29, 30 and 35 all beginning with a clause: *When I have distressing thoughts or images*. Understandably, even though it was not our intention, the respondents often assumed that the repetitive/redundant structure was done on purpose in order to increase validity and to strengthen internal consistency. While these are important objectives for surveys, they tend not to be for heuristics.

Wordiness and excessive length as well as lack of clarity of some characteristics emerged as problematic. Accordingly, the respondents commented that some characteristics were too long, too wordy, too whimsical, too esoteric, difficult to respond to, unclear, confusing and not easily identifiable with other characteristics. One such case was characteristic #6: *I experience my thoughts more as events in my mind than as a necessarily accurate reflection of the way things 'really' are*.

Another challenge in the heuristic was that as many as ten characteristics were categorized as *reverse scored*. Therefore, they were negative characteristics as far as mindfulness is concerned. For example, characteristic #3: *When I do things, my mind wanders off and I'm easily distracted* refers to a mind wandering and inability to focus which is typical of non-mindful conduct. Similarly, characteristic #4: *I criticize myself for having irrational or inappropriate emotions* does not agree with mindfulness, which is characterized by acceptance of all emotional states and an effort to refrain from judging oneself. We felt that the reverse-scored characteristics did not align well with the reflection-invoking function of a heuristic. Reflecting on what mindfulness is rather than what it is not made more sense. We thought that alignment with the mindfulness construct was what should set our tool apart from a survey that adheres to certain psychometric features.

A further limitation of this version of a heuristic was that some characteristics combined distinct concepts such as (1) *feelings* and *emotions* as in #5, (2) *thoughts* and *feelings* as in #33, or (3) *thoughts* or *images* as in #11, 29, 30 and 35. We agreed with the collaborators who noted that some words whose meanings were close to each other appeared as if they were interchangeable. Characteristic #8: (*I can easily put my beliefs, opinions and expectations into words*) may be representative of this issue. We decided that for clarity purposes each of the distinct ideas needed to be teased apart and included in separate characteristics.

Finally, we received a fair number of comments regarding the rating scale. Some respondents were uncomfortable with *never* and *always* being part of the scale. In addition, a suggestion was made to remove the word *true* from the scale and just retain frequency words. This comment aligned well with our stance that rejects ontological realism in favor of polysemia. We accepted the suggestion that the scale should be reversed, starting with "positive" and ending with "negative", i.e., from *very often* to *very rarely*. The flexibility of a heuristic includes changing the nature of the rating scale and even forgoing the rating scale if a person does not want to use

it. In fact, a heuristic could be delivered as a narrative or a story that might be appealing to different audiences including young children or senior citizens.

Ever-Present Contradictions

While the majority of our colleagues enthusiastically embraced the process of the heuristic development, at least one of them challenged our seemingly "unmindful" and "scientific" approach to discussing mindfulness. At that stage we were fully aware that our efforts to make mindfulness concrete by identifying facets of mindfulness might be perceived as incomplete and reductive. Furthermore, identifying 35 characteristics for those facets was even more reductive. We did not want to take an essentialist stance that implied we had fully described mindfulness in terms of seven facets and associated characteristics. On the contrary, we began with the idea of transcendence and the benefit of offering insights by providing descriptions of what mindfulness was and was not even though this could never be determined fully by categories and lists. Like any other concept, once a person starts to build up a repertoire of what belongs to it and what does not belong, there is a growing hermeneutic awareness that begins to define the construct in ways that are fluid and dynamic.

Another contradiction came from one of the avid yoga practitioners who felt that the instrument fell short of meeting its goal. While others pointed to the extensive length of the heuristic, he found it to be short in terms of getting an accurate assessment of people's "true mindfulness." He advocated that a more meaningful heuristic would be possible if more questions were to be put forth in different ways. This comment resonated with us and, ultimately, we expanded the heuristic to include dimensions of mindfulness (such as loving kindness and compassion) that were missing from its early iterations.

Consistent with the emergent design of our interpretive research (Erickson 1998), we expected and were open to making evolutionary adjustments to the mindfulness heuristic. This approach is grounded in our axiological stance that values difference and complexity as resources for learning (Tobin 2010).

Second Iteration of the Heuristic

In addition to gathering and analyzing the comments made by our respondents, we decided to take advantage of the quantitative data obtained through the use of the rating scale. We were curious to see if analyzing underlying statistical structures might assist us further in refining the heuristic. Using SPSS, we performed factor analysis of 37 responses to the heuristic and arrived at a 6-factor solution. At this stage, we thought it was useful to retain all six of these factors and to sharpen the characteristics accordingly. In addition, the factors could be used as a basis for

selecting characteristics to provide a shorter version of the mindfulness heuristic. Because of the way they were selected, these characteristics could be used heuristically to think about mindfulness but we did not expect them to load on a single factor nor did we expect them to aggregate together to form a measure of mindfulness. In other words, psychometrically it made more sense to consider a construct that was multidimensional in nature. It would not be appropriate to sum the scores provided on the heuristic to obtain a single measure of mindfulness. Instead there was at least an empirical rationale for producing separate scores for each construct.

Following Frederick Erickson's (1998) recommendation, we were now armed with a variety of kinds, sources and amounts of evidence and ready to proceed with transforming the heuristic. Statistical analyses were not laid out as evidence for any particular stance but instead they were used to show patterns and contradictions that provided alternative insights into the construct of mindfulness. It was not our intention to present any of the analyses as truths and we did not search for coherence among the different analytical tools we used. Once again, our stance was part of an axiology that is neither monosemic nor monophonic but radically polysemic and polyphonic.

Upon closer inspection, we discovered that our statistical outcomes were not in alignment with the respondent comments. In many cases, characteristics that loaded most heavily on a particular factor were "flagged" as problematic by our collaborators. It was becoming more and more clear that the heuristic was in need of a major overhaul and it made little sense to try to "rescue" any particular characteristics drawn from the original pool. To that end, it was time to finally bid farewell to the psychometric characteristics in our tool, starting with the elimination of characteristic redundancy as well as removal or re-wording of the reverse-scored characteristics.

A feature of a heuristic that makes it different from a survey is that characteristics are selected to cover the field of the construct, making sure that characteristics positioned around the boundaries as well as those in the center are included. That is, a heuristic pays attention to difference as well as central tendency. Making sure that characteristics are coherent, in the way that the items that define a survey should be coherent, is not a goal. Instead care is given to make sure that characteristics that are "the essence" of a construct are represented in the heuristic.

As we were breaking ties with anything that might suggest our heuristic having any psychometric aspirations, a few of us participated in the Annual Conference organized by the Mindfulness in Education Network. There we came in contact with the work of Sharon Solloway, the author of the Solloway Mindfulness Survey (SMS). Similar to us, Solloway conducted studies with students in a pre-service teacher education program (though in her case the participants were in an undergraduate program). She argued that mindfulness practice is measurable, teachable and learnable, and may be an object of experimental research. Additionally, like us, she and her collaborator developed the scale through a hermeneutic integration of qualitative (drawing on students' journal entries) and quantitative (using Rasch model) processes (Solloway and Fisher 2007). Solloway claims that this approach allowed her to translate the cumulative voices of her students into a scale that

corroborated their journal entries retaining the individuality of experience just as the journal entries did. When we reviewed her scale, we were drawn to the idea that for some of the SMS items, the respondents were asked to describe in their own words what the item meant and to write an example from their life. Since we were deeply concerned with creating opportunities for reflective pauses, we decided that we would provide space for free-flowing reflections over each of the characteristics in our heuristic. Such an approach would allow for making even deeper connections with each mindfulness trait.

A strong influence on reshaping the heuristic came from Richard Davidson's seminal work in *affective neuroscience* (the study of the brain basis of human emotions). In his 2012 co-authored book, that was released as we were engaged in our research, Davidson identified unique neural signatures for *Emotional Styles* that underlie human personalities and traits. Davidson demonstrates the power of neuroplasticity (the brain's ability to change its structure and function) in altering Emotional Styles through contemplative practices such as mindfulness. For example, *resilience* is a measure of how quickly one recovers from adversity. Davidson's experiments show that strengthening and increasing the connections between the left prefrontal cortex and the amygdala through mindfulness practices can increase resilience.

This idea that our Emotional Styles can be transformed through practices that modify our brains has very important implications for education. For example, a teacher's (or a student's) low *outlook* (inability to maintain a positive emotion) or poor *attention* skills (how sharp and clear one's focus is) may have devastating consequences for school performance. Both *outlook* and *attention* may be improved through mindfulness meditation, which fosters concentration, promotes compassion and kindness, and consequently may create a happy and optimistic classroom in schools. Davidson's findings resonated with us in light of our work on emotions in education and our interest in self-regulating emotional states. Raising *self-awareness* (how well one can perceive bodily feelings that reflect emotions) aligned well with our efforts to assist teachers in making a connection between emotions and their physiological markers such as heart rate and breathing pattern. We were also interested in increasing levels of *resilience* (ability to recover from adversity or not getting stuck with a particular emotion as was often the case with Rey Llena). We concurred with Davidson that being mindful about areas of potential brain activity could be associated with gaining some control over them. For this reason, we thought it important to develop one or two characteristics for each of the six dimensions of Emotional Style and weave them into the heuristic (see Table 3.2 for examples of the new characteristics).

We found it intriguing that Paul Ekman, whose best-known work is on the universal elements in emotion, was proclaiming a strong interest in how each individual's emotional experience is unique. What Davidson labels Emotional Style dimensions, Ekman (2003) appears to refer to as "emotional profiles" (p. 238). Similar to scholars with interests in contemplative practices, Ekman acknowledges that emotional behavior awareness and impulse awareness may be accomplished through mindfulness meditation.

Table 3.2 Emotional style dimensions as represented in the mindfulness heuristic

Emotional style dimension	Meaning	Related mindfulness characteristic
Resilience	How quickly you recover from adversity	6. I quickly recover when things go wrong for me
Outlook	How long you are able to sustain positive emotion	10. I maintain a positive outlook on life
Social intuition	How adept you are at picking up social signals from the people around you	11. I can tell when something is bothering another person just by looking at him/her
Self-awareness	How well you perceive bodily feelings that reflect emotions	9. When I am emotional, I notice changes in my heartbeat
Sensitivity to context	How good you are at regulating your emotional responses to take into account the context you find yourself in	13. The extent to which I show my emotions depends on where I am
Attention	How sharp and clear your focus is	14. If I decide to focus my attention on a particular task, I can keep it there

Finally, we felt that our heuristic would not be complete without the other wing of mindfulness – loving kindness and compassion. Therefore, we added a few characteristics relating to loving kindness as in #15: *I am kind to* others, as well as to compassion to self as in #5: *I am compassionate to myself when things go wrong for me* and to others as in #16: *I feel compassion for people even if I do not know them.* Compassion was somewhat related to a non-judgment factor (taking a non-evaluative stance toward cognitions and emotions) in the earlier version of the heuristic. We discovered an interesting pattern among teachers in our study – in their responses to the heuristic they indicated that while they were compassionate to others they were often "hard" on themselves. In follow-up conversations, we were told that raising compassion to self and increasing *resilience* levels were among desirable outcomes for the study participants not only in the teaching/learning context but also in other fields of social life.

After adding the loving-kindness and compassion characteristics, the second iteration of our heuristic was complete. Now consisting of seventeen characteristics, the heuristic reflected ten dimensions of what Tobin refers to as *mindful action* (see Figs. 3.2 and 3.3).

Third Iteration of the Heuristic – Mindfulness in Education

Since our interest is in education in general and in science education in particular, the next and natural progression was to contextualize the heuristic to teaching and learning. Our collaborating colleagues liked the idea of "making educational contexts more reflexive places." They considered mindfulness "not only important but

- Being aware of surroundings, emotions and what you are doing
- Maintaining focus
- Being kind
- Acting with compassion
- Recovering from adversity
- Maintaining a positive outlook
- Being socially intuitive
- Adapting actions to context
- Separating emotions from other actions
- Suspending judgments about emotions

Fig. 3.2 Ten dimensions of mindful action

1. I am curious about my feelings as they occur.
2. I easily find words to describe my feelings.
3. I observe my thoughts without being caught up in them.
4. I perceive my emotions without having to react to them.
5. I am compassionate to myself when things go wrong for me.
6. I quickly recover when things go wrong for me.
7. I pay attention to sensations, such as the wind in my hair or sun on my face.
8. When I am emotional, I notice how my breathing changes.
9. When I am emotional, I notice changes in my heart beat.
10. I maintain a positive outlook on life.
11. I can tell when something is bothering another person just by looking at him/her.
12. The extent to which I show my emotions depends on where I am.
13. The extent to which I show my emotions depends on whom I am with.
14. If I decide to focus my attention on a particular task, I can keep it there.
15. I am kind to others.
16. I feel compassion for people even if I do not know them.
17. When I produce strong emotions, I can easily let them go.

Fig. 3.3 Characteristics in the second iteration of the mindfulness heuristic

necessary for holistic development, which constitutes science education also." Therefore, early on, contextualizing the heuristic appeared to be a preference of our collaborators. What we did with characteristic #14 may be an example of adapting it to educational contexts. A generic statement: *If I decide to focus my attention on a particular task, I can keep it there* became a specific characteristic: *I can focus my attention on learning*. Similarly, an earlier characteristic referring to *social intuition*: *I can tell when something is bothering another person* was replaced by two

related characteristics: *I can tell when something is bothering the teacher* and *I can tell when something is bothering other students*. Conversely, a somewhat specific earlier characteristic: *I pay attention to sensations, such as the wind in my hair or sun on my face* became more reflective of a windless and sunless classroom setting in *I pay attention to my moment-to-moment sensory experiences*.

What we were hermeneutically learning from the study with the pre-service and in-service science teachers constituted another impetus for implementing modifications to the heuristic. The characteristics of a heuristic are expected to constantly change to fit the contexts of research including the axiologies (what is valued), ontologies (how life is experienced), and epistemologies (what constitutes knowledge) of participants. Thus, what an individual would be mindful about would depend on the circumstances being considered and would be included in the heuristic. Often we use the metaphor of "shape shifter" to convey the idea that a heuristic can change its shape even though a construct, such as mindfulness, might remain the same from one context to another. Because our study focused on raising awareness of emotions, their physiological manifestations, as well as ways of regulating emotional states, a pool of relevant characteristics was expanded and gained prominence in the new version of our heuristic. Thus, informed by Tobin's earlier studies on prosody and proxemics and the work of Ekman (2003), Turner (2002) and Collins (2004), we included characteristics referring to the awareness of the expression of emotions in voice, face, and body movements in addition to body temperature, breathing patterns and pulse rates. Furthermore, we added three characteristics referring to a high-grade intervention involving the management of emotions through breathing meditation that we developed and enacted as part of the study. Awareness of the emotional climate in the classroom was yet another ingredient of our study and necessarily found its reflection in the heuristic (*I am aware of emotional climate and my role in it*). Finally, we considered it essential to incorporate characteristics that would be reflective of the individual | collective dialectic (the vertical line indicates a dialectical relationship) that is typical of teaching/learning environments. Dialectical relationships refer to constructs in social fields that are a constituent of a whole and do not exist independently – existence of one presupposes the other (see Gene Fellner, Chap 2 this volume). An example of a pair reflective of such a relationship is a "collective" characteristic #20: *I recognize others' emotions by looking at their faces* and its "individual" counterpart #21: *I am aware of my emotions as they are reflected in my face*. Even though the number of characteristics in the new heuristic nearly doubled as compared to the previous version, they all reflected salient aspects of our study without redundancy (see Fig. 3.4). This transformation made it easier for the study participants to identify with each of the mindfulness characteristics included in the heuristic.

During this class:

1. I am curious about my feelings as they rise and fall.
2. I find words to describe the feelings I experience.
3. I identify distracting thoughts but let them go (without them influencing future action).
4. I am not hard on myself when I am unsuccessful.
5. I recover quickly when I am unsuccessful.
6. I pay attention to my moment-to-moment sensory experiences.
7. I am aware of the relationship between my emotions and breathing pattern.
8. I am aware of changes in my emotions and pulse rate.
9. I maintain a positive outlook.
10. I can tell when something is bothering the teacher.
11. I can tell when something is bothering other students.
12. The way in which I express my emotions depends on what is happening.
13. The way in which I express my emotions depends on who is present.
14. I can focus my attention on learning.
15. I feel compassion for myself when I am unsuccessful.
16. I feel compassion for others when they are unsuccessful.
17. When I produce strong emotions I easily let them go.
18. I gauge my emotions from changes in my body temperature.
19. I am aware of others' emotions from characteristics of their voices.
20. I am aware of my emotions being expressed in my voice.
21. I recognize others' emotions by looking at their faces.
22. I am aware of my emotions as they are reflected in my face.
23. My emotions are evident from the way I position and move my body.
24. The way I position and move my body changes my emotions.
25. I can tell others' emotions from the way they position and move their bodies.
26. I am aware of emotional climate and my role in it.
27. Seeking attention from others is not important to me.
28. Classroom interactions are characterized by winners and losers.
29. I meditate to manage my emotions.
30. I use breathing to manage my pulse rate.
31. I use breathing to manage my emotions.

Fig. 3.4 Characteristics in the mindfulness in education heuristic

Uses of Heuristics

A heuristic is meant to be a malleable tool fitting any context. Its flexibility also lies in its multiple uses. The first use is as a low-grade intervention. As noted earlier, the theory that supports low-grade interventions is reflexive inquiry where we ask participants to complete the heuristic thereby making them aware of the characteristics

and their relative occurrences. We theorized that becoming aware in this way would catalyze changes in practices. During our study, we found evidence suggesting that this is exactly what happens. A second use of the heuristic may be for planning where individuals involved in an activity, such as coteaching, use the characteristics and plan accordingly so that the relative occurrence of those characteristics could be targeted to reach desirable levels. Third is the use of the heuristic as a framework for interpretive inquiry concerning what happens in a social field. Hence, mindfulness heuristics may be used to describe what is happening in the science classroom from a hermeneutic phenomenological perspective. A fourth use is in undertaking landscape studies. The presence of the rating scale allows a heuristic to be used to portray landscapes (descriptions of the amount of mindfulness that crops up) for individuals and/or collectives. For each characteristic, a time series plot could be made for an individual to show how conduct in relation to the characteristic changes with time. Similarly, measures of central tendency and dispersion could be obtained for each characteristic for a collective as an illustration of patterns and contradictions. The calculation of parameters such as mean, mode, median along with appropriate measures of dispersion such as minimum, maximum, range, standard deviation, variance is a typical feature of a landscape study. It needs to be emphasized that the purpose of a landscape study is not to generalize to a population of which either the participants or the characteristics are a random selection. In the type of research in which we engage the participants are carefully selected and so are the characteristics for a social construct such as mindfulness.

In order to illustrate these four uses of heuristics, let us consider week 12 in our 15-week long study with the graduate students of a science-teacher-education program. The topic of the class was evolution. The instructor, his students and the research team anticipated this controversial topic (like many others covered in this course) to invoke high emotional states. The three students who volunteered to coteach that week (Aga, Aimee and Edward) decided to consider mindfulness characteristics when preparing for, executing and reflecting on their presentation. I worked closely with the group and we videotaped and analyzed our prep meetings, the class itself and the post-class discussions. At the forefront of all these activities was the pervasive awareness of, sensitivity to and respect for the ontological, axiological and epistemological standpoints of both the presenters (all very passionate about the theory of evolution) and other class participants (representing a wide spectrum of attitudes towards the theory in its entirety or its parts). Of the three presenters, Aga and Aimee, who became actively involved in our research, often commented on how considering mindfulness assisted them in preparing and coteaching the class. They also attributed their personal transformations to their participation in the research and being exposed to the enacted interventions, including mindfulness heuristics. In Aga's case, it was reconsidering the value of scientism with its dismissive attitude towards alternative ways of knowing. The manuscript Aga co-authored with the class instructor provides a more complete account of her experience (Alexakos and Pierwola 2013). For Aimee, who considers herself "overemotional," mindfulness was a way of learning how to replace *reacting* with *responding*. As evident in the following quote, awareness development was the first important step for her:

> I'm trying to bring mindfulness into my life generally. The other day at work I was having a conversation with one of my bosses and I noticed I was raising my voice; I was getting defensive. One of my other managers had to step in. He said, "You know, Aimee, you're getting too aggressive; he is your supervisor." And I was like, "Oh, God, if I really can't contain myself even with my boss what am I going to do in the future if I'm talking to the principal."

As I noted earlier, the next step associated with a low-grade intervention may be making a decision whether a change in one's habitus is desirable. Coming to and enacting such a decision (as in Aimee's case a move "to put a lid on" emotions) may prove challenging:

> I'm actually kind of stuck here because part of me doesn't want to change myself, like, I think it's kind of, like, giving in if I say I have to put, like, a lid on it. But, at the same time, I have to, like, get by, right? Like, control my display.

In this course, heuristics were one of the methods to bring mindfulness characteristics to the awareness of the participants. Week 12 is an example of how heuristics were used as a planning tool (by assisting in enacting a mindful presentation) and, simultaneously, perhaps dialectically, as an intervention that ignited a reflection over one's way of being in the world. When heuristics are applied in these ways, they contribute to meeting authenticity criteria that guide our research. The idea behind authenticity criteria is for the research participants to benefit from research. The benefits may translate into improved practices and wellbeing.

In applying the heuristic as a framework for interpretive study, one might focus on certain mindfulness characteristics. For example, let us consider two characteristics that link emotions with their physiological markers: breathing patterns and heart rate. In our study, through the use of oximeters worn by the students during coteaching activities, we were able to record students' heart rate and oxygenation levels in their blood. Both Aga and Aimee were extreme cases of what may happen when individuals are involved in teaching. While Aga's oxygen level dropped considerably, Aimee's heart rate soared to a level unmatched by any other student in the class. Of note was the fact that, like many others in their class (and possibly in classes across our educational system), Aga and Aimee were not aware of what was happening to them. As the course progressed, however, we witnessed heightening of awareness of the connection between in-the-moment emotions and physiology as well as an increased ability to rein in strong emotions. In addition, students reported that their newly acquired practices seeped into other fields of their daily lives. As part of the course requirement, each student was responsible for coteaching twice during the semester. We were able to record the drop of heart rate level between the early and late instance of many student presentations. In the case of Aga and Aimee, the raising awareness associated with relevant mindfulness characteristics may also be illustrated through how they responded to the heuristic. We administered the 17-characteristic heuristic at the beginning of each class starting with week 10 and ending in week 12. In this instance, in addition to its other functions, a heuristic became a tool for undertaking a landscape study. Aga's rating for the awareness of changes in her breathing associated with being emotional (characteristic #8) was the

Table 3.3 Change in means of characteristic #9 over three administrations of the Mindfulness Heuristic

(I) Time		Mean difference (I-J)	Std. error	Sig.[a]	95 % confidence interval for difference[a]	
					Lower bound	Upper bound
Week 10	Week 11	0.000	.243	1.000	−.514	.514
	Week 12	−.471*	.194	.027	−.882	−.059
Week 11	Week 10	0.000	.243	1.000	−.514	.514
	Week 12	−.471*	.174	.016	−.839	−.102
Week 12	Week 10	.471*	.194	.027	.059	.882
	Week 11	.471*	.174	.016	.102	.839

Based on estimated marginal means
*The mean difference is significant at the .05 level
[a]Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments)

highest in week 12. For Aimee, her awareness of heart rate (characteristic #9) increased in week 11 and stayed at that level through week 12. Thus both Aga and Aimee exercised agency in gaining control over their wellbeing. When we analyzed change over time among 17 students who participated in the three administrations of the heuristic, increase in the mean score between weeks 10 and 12 and between weeks 11 and 12 were statistically significant ($p<0.05$) for characteristic #9 (see Table 3.3). Other characteristics that displayed increase in the mean scores included #4 (separating emotions from other actions), #7 (self-awareness), #10 (maintaining a positive outlook), #13 (being socially intuitive) and #16 (acting with compassion). The rise in ratings may indicate that these characteristics may have been salient to students in our study. Thus, we might argue that the class became more mindful in respect to these characteristics. In fact, we found that the difference in the means of the combined characteristics obtained for weeks 11 and 12 was also statistically significant ($F=23.4$, $p<0.001$). I provide more examples of how we used heuristics in my chapter in an edited volume detailing many aspects of our study (Powietrzynska forthcoming).

The "So What?"

With its calming effect, mindfulness has clear implications for the field of education where it is slowly gaining traction. It may help to ameliorate stressful thoughts and emotions and quiet down racing hearts of teachers like those in our study. In turn, mindful teachers may be able to assist their students in adopting mindful conduct. This chapter presents one approach to developing a reflective tool, a heuristic, that may be used by educators interested in raising mindfulness in their classrooms. We hope that through the use of the heuristic, students and teachers will become aware

of what mindfulness is and will take steps to becoming more mindful. We hope that like many of the novice teachers in our study, they will experience breakthroughs of making a connection between learning and teaching and mindfulness. We invite our colleagues to adopt and/or redesign any of the three versions of the mindfulness heuristic to fit their particular contexts and needs. We hope that our research will create ripple effects of transformations within and beyond the field of education. We also believe that this research will contribute to an emerging science of teaching and learning, which we regard as a central constituent of teacher education. Included in this chapter is a list of mindfulness-related resources we offer to those whose interest in the topic is inspired by our work (see list below).

Here is a list of on-line resources related to mindfulness. Many websites will offer links to additional resources including mindfulness-related research literature.

Amishi Jha's Lab
http://www.amishi.com/lab

Association for Contemplative Mind in Higher Education
http://www.acmhe.org

Association for Mindfulness in Education
http://www.mindfuleducation.org

Center for Compassion and Altruism Research and Education, Stanford University
http://ccare.stanford.edu

Center for Mind and Brain, UC Davis
http://mindbrain.ucdavis.edu

Center for Mindfulness in Medicine, Health Care, and Society (founded by Jon Kabat-Zinn), University of Massachusetts
http://www.umassmed.edu/cfm/home/index.aspx

Center for Investigating Healthy Minds
http://www.investigatinghealthyminds.org

CUNY Contemplatives' Wiki
http://cunycontemplatives.pbworks.com

Garrison Institute
http://www.garrisoninstitute.org

Garrison Institute CARE (Cultivating Awareness and Resilience in Education)
http://www.garrisoninstitute.org/contemplation-and-education/care-for-teachers

Lab for Affective Neuroscience (founded by Richard Davidson), University of Wisconsin
http://psyphz.psych.wisc.edu/web/index.html

Learning to BREATHE
http://learning2breathe.org

Mindfulness Awareness Research Center, UCLA
http://marc.ucla.edu

Mindfulness and Education Working Group, Teacher's College
http://www.tc.columbia.edu/centers/mindfulness

Mind & Life Institute
http://www.mindandlife.org/

Mindfulness for Teachers and Students in NYC
http://www.learnmindfulnessnyc.com/teachersstudents

Mindfulness in Education Network
http://www.mindfuled.org

Mindfulness Research Guide
http://mindfulexperience.org

Mindful Schools
http://www.mindfulschools.org

Omega
http://eomega.org

The Hawn Foundation – MindUP™ Program
http://www.thehawnfoundation.org

The Inner Resilience Program
http://www.innerresilience-tidescenter.org

Santa Barbara Institute for Consciousness Studies (founded by B. Alan Wallace)
http://www.sbinstitute.com

The Still Quiet Place
http://www.stillquietplace.com

Solloway Mindfulness Scale & Resources
https://dts.lectica.org/mindfulness/SMS/m-intro.html

Washington Mindfulness Community
http://mindfulnessdc.org

Waisman Laboratory for Brain Imaging and Behavior
http://brainimaging.waisman.wisc.edu

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Chapter 4
Studying Secondary Science Student Teaching Experiences Within a Cohort Community of Practice: A Multi-planar, Multi-analysis Sociocultural Methodology

Jennifer Gallo-Fox

While the student teaching experience is the most widely studied component of the field of teacher education (Feiman Nemser 1983), this is not the case for the more specialized field of science teacher education. In science teacher education, research typically examines preservice teacher conceptual change and science methods (Russell and Martin 2007). The science practicum experience has been less frequently studied, and there is a limited knowledge base about the experience of learning to teach secondary science during preservice student teaching. Historically, in teacher education, practicum components are studied using interview and observational data sources that focus on preservice teachers' instructional experiences. But is that enough to fully understand the process of learning to teach science? It has been argued that there is a need for broader understanding of the process of learning to teach with attention to the collective learning experience, and the role of the learning context and ecology (Clift and Brady 2005). Methodological approaches that utilize sociocultural theoretical frameworks could provide additional insights about the process of learning to teach high school science.

This purpose of this chapter is to articulate a multi-planar, multi-analytic methodological approach for studying student teaching experiences. The goal is not to present a detailed empirical study, but rather to highlight ways that this approach can be used to study sociocultural learning experiences within community, and to discuss implications for future research in science teacher education. Specifically, this methodology incorporates multiple qualitative research traditions to study experiences learning to teach science across multiple sociocultural planes of development (Rogoff 1995). By analyzing data across different planes of development one is able to gain insight into the spectrum of learning experiences that occur

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during a coteaching full practicum experience. The multiple analyses illuminate the learning experience and coalesce through the use of crystallization imagery (Richardson 2000).

I begin this chapter with a discussion of sociocultural frameworks used to shape this work. I then present the methodology. Next, I illustrate the potential for this methodological approach using examples from a study of the learning experienced by secondary science preservice teachers who participated in a cohort coteaching model for their student teaching experience. I conclude the chapter with a discussion of the implications of this approach for the field.

Sociocultural Frameworks

Etienne Wenger (1998) writes, "Our perspectives on learning matter: what we think about learning influences where we recognize learning" (p. 9). Historically, the student teaching, or full practicum, experience has been viewed as the place where preservice teachers apply theories learned in formal teacher education courses. As such, the research on practice frequently examines preservice teachers' application of ideas from the university. The empirical research and literature reviews about field experiences suggest that additional research is necessary to better understand the student teaching experience, and that new questions and theoretical frameworks will enable novel understandings (Clift and Brady 2005). Using a sociocultural framework of learning can enable new insight into the landscape of student teaching, and open up questions about the role of context and the process of learning to teach within the student teaching setting.

From a situated perspective "the physical and social contexts in which an activity takes place are an integral part of the activity, and that the activity is an integral part of the learning that takes place within it" (Putnam and Borko 2000, p. 4). A key tenet of sociocultural theories of learning is that learning occurs through participation (Lave and Wenger 1991) and that outcomes of these learning experiences include the development of the practices of the community. In order to understand what is learned and how learning occurs, researchers need to develop a thorough understanding of the context and the cultural expectations within the setting. Numerous sociocultural theorists have argued that joining a new community prompts new members to develop ways of speaking, thinking, and behaving of the group. This process of becoming recognized as a member of a community has been called "legitimate peripheral participation" (Lave and Wenger 1991) and also the development of "Discourse" (Gee 1992). Development of community Discourse is part of the process of identity development and leads toward recognition as community members.

A Multi-planar, Multi-analysis Methodology

This research methodology enables researchers to study the types of learning opportunities and sociocultural experiences afforded in a professional community. Sociocultural learning experiences can be examined across multiple planes of development (Rogoff 1995). In this methodology multiple analyses are conducted to achieve this. Crystallization imagery (Richardson 2000) is then utilized to bring together the multiple analyses. Description of these approaches follows.

Barbara Rogoff (1995) argues that when studying development one can examine the experience across three different planes of development: community, interpersonal, and personal. While learning occurs concurrently in each of these areas, examining them simultaneously is difficult due to the complexity of the experience. Rogoff's framework foregrounds one plane of learning at a time while acknowledging the "mutually constituting" (p. 144) nature of each. This approach enables researchers to focus on a particular aspect of the situated learning experience and provides a lens for analyzing participant experiences within the larger community experience.

Merging research traditions provides a researcher with multiple tools for examining a phenomenon. James Gee and Judith Green (1998) demonstrated that when studying sociocultural learning experiences researchers can successfully merge multiple qualitative research traditions. They noted that researchers must utilize methodologies that best suit the research question, and do so in theoretically appropriate ways. In their sociocultural study they utilized ethnographic traditions and discourse analysis. For the study discussed here, multi-planar analyses of learning within community required reorganization of the data set, use of different units of analysis, and use of multiple qualitative methodologies.

The multiple analyses are then brought together to develop a coherent understanding of the experience. Crystallization imagery is a way to coalesce findings in "postmodernist mixed-genre texts" (Richardson 2000, p. 934). Laurel Richardson writes,

> The central imaginary is the crystal, which combines symmetry and substance with an infinite variety of shapes, substances, transmutations, multidimensionalities, and angles of approach … Crystals are prisms that reflect externalities *and* refract within themselves creating different colors, patterns, and arrays casting off in different directions. What we see depends upon our angle of repose. (Italics in original, p. 934)

Building on Richardson's work, I draw on the metaphor of a crystal with multiple faces and vantage points for interpreting the experiences of learning in community. The crystal provides a means to draw together the multi-planar analyses of the learning community. When the multiple findings are merged, they serve as facets of a crystal, creating multiple, differently positioned understandings of the experience. Collectively, these insights illuminate the learning process within the community. The discussion that follows illustrates how this methodological approach was used to study an alternative model for learning to teach within a full practicum coteaching community of practice.

Applying This Methodological Approach: Studying a Coteaching Community of Practice Across Multiple Planes of Development

Coteaching is a process of learning to teach that involves teachers at multiple points in their careers (preservice, inservice, and also occasionally university faculty) who teach together in order to learn *in-situ* (Tobin 2006). Coteaching is a mutual process where teachers share classroom responsibilities and expectations. State University's model of coteaching pairs student teachers and places them with multiple cooperating teachers. In Spring 2005 a cohort of eight coteaching student teachers were placed with eight cooperating teachers all within the science department at Biden High School (all names are pseudonyms). The teaching placement was a 16-week full practicum teaching experience in which the student teachers cotaught four out of five class periods each day, and "solo" taught one class period. Solo classes followed a more traditional model of student teaching where student teachers assumed independent responsibility of the class. The preservice and inservice science teachers cotaught together. Their practice was grounded in the science content areas that they taught: anatomy and physiology, biology/forensics, chemistry, environmental science, and 9th grade general science with a focus on earth science, chemistry, and physics. Throughout the day they cotaught and utilized content specific pedagogies.

Multiple data sources were collected about the teaching experience. These included student teacher and cooperating teacher interviews, field observations, audio data of coplanning meetings and on-sight seminars that were attended by both the student teachers and cooperating teachers, and program documentation (see Fig. 4.1).

The coteaching community of practice was studied using the multi-planar, multi-analytic approach. Analysis examined the process of learning to teach within the coteaching community of practice at the community level, micro-community level, interpersonal, and personal levels. I began analysis of the community learning experience by studying the community plane through general qualitative and ethnographic approaches. For this analysis, the entire coteaching community of practice was studied to develop an understanding of the types of cultural practices of all 16 coteachers. Data illuminated the fact that coteachers interacted in a wide variety of settings with varying groups of people using different norms for practice. Secondary analysis of the community plane experience was conducted using comparative cross-case analysis (Miles and Huberman 1994). This analysis enabled me to study contextual differences between sub-groups of coteachers (*micro-communities)*. Next, interpersonal interactions of a group of three coteachers were studied through the use of discourse analysis with a focus on semiotics. This analysis illuminated the ways that coteachers worked together to develop plans for practice and extend their thinking about instruction. Finally, in order to study participant development on the personal plane, data pertaining to individual participants were studied using qualitative methods. Figure 4.2 presents this multi-planar, multi-analytic process and delineates the research methods used for each plane of development.

Participants	Data Source	Frequency	Totals
Eight teaching interns and eight cooperating teachers	**Interviews**		
	• Intern	Three formal interviews with an average of 3.5 hours per intern	Twenty-eight hours of intern interviews
	• Cooperating teacher	Two formal interviews about one hour each	Sixteen hours of cooperating teacher interviews
	Observations		
	• Fieldnotes	Each intern was observed at least 20 times over fifteen weeks	
	Recordings of meetings		
	• Coplanning sessions	A minimum of two per participant	Twenty coplanning sessions
	• Seminars	Five seminars located at BHS attended by interns and cooperating teachers	Five seminars
	Program Documentation		
	• Fall methods course syllabus, intern reflective journal entries, weekly schedules and lesson plans, miscellaneous instructional materials		

Fig. 4.1 Data sources

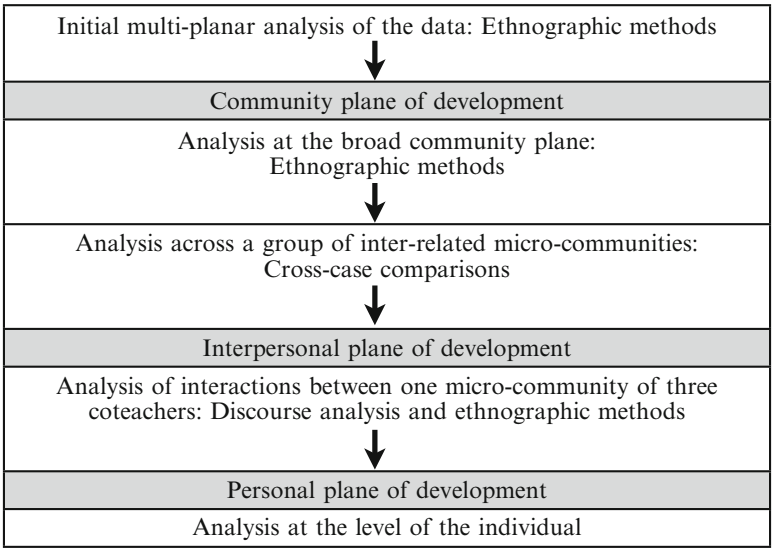

Fig. 4.2 Multiple analyses focused in on increasingly narrower planes of development using differing analytical methods

As will be discussed later in the chapter, each layer of analysis illuminated different aspects of the sociocultural learning experiences that occurred within the coteaching community of practice. This research as a whole illuminated the fact that across these experiences the preservice teachers developed the Discourses (Gee 1992) of the community and professional identities as high school science teachers. The discussion that follows describes analyses for each the three planes and identifies the learning and practices the preservice teachers developed at each level.

Broad Level Analysis of Cultural Practices at the Community Plane

Most studies of practicum experiences focus on the student teachers' instructional experiences, however, opening up the research lens beyond these experiences poses opportunities for understanding the way that sociocultural contexts impact teachers' practice (Warren 1969). Using data generated across the 16-week student teaching semester, data were analyzed across the full coteaching day. It was found that all coteachers (student teachers and cooperating teachers) moved between a wide range of contexts, types of activities, and Discourses during each day. Types of activities included: formal coplanning meetings, coteaching, solo teaching, lunch, morning gatherings when teachers geared up for the day, informal preparation periods, quick exchanges between classes, lunch, informal debriefing, and work at home. These varied activities took place in a range of contexts such as different classrooms at Biden High, in the faculty lounge, in hallways, and carpools. Furthermore, depending on the context and who was present, different Discourses, or ways of acting and talking, were the norm. As part of their work within the community of practice, the preservice teachers learned to move seamlessly between these spaces participating in ways similar to their more experienced community members, the cooperating teachers.

Findings from data analysis of the community plane illustrate how through participation within the coteaching community of practice at Biden High School student teachers were exposed to the pacing and rhythm of the school day from the teachers' perspective. Experiences at this level were connected to the process of becoming a member of the community of practice and learning how to look, act, and feel like a high school science teacher. For example, during school assemblies the preservice teachers roamed the aisles staring down students who were talking, or being disruptive. They also sat and interacted casually with colleagues over breakfast and lunch, and engaged in focused conversations about curriculum and instruction during planning meetings.

Analysis of sociocultural learning experiences at the community plane of analysis reveals that preservice teacher participation at the community level encompassed the broad activities and the overarching culture of teaching within the science department at Biden High School. These experiences afforded student teachers with opportunities to learn how to participate in the practice of teaching, and also how to interact professionally with colleagues, students and other community stakeholders.

Micro-community Practices

All participants participated in the broad activities of the community. However, throughout the day, different combinations of student teachers and cooperating teachers worked together. Each student teacher participated in two or three different coteaching groups. When the entire data-set was re-organized according to these cases (Miles and Huberman 1994) and analyzed accordingly, it became apparent that each coteaching group had different Discourses of practice. I call these collaborative coteaching workgroups *micro-communities*, because each of these sub-communities developed their own Discourses including local language, local teaching tools and practices, and constructed their roles and interactive practices differently.

Two student teachers, Javier and Julie, participated in both the Environmental Science and 9th Grade Academy micro-communities. In these micro-communities, the coplanning and coteaching practices were notably different. In this section, I describe these differences through a discussion of Julie and Javier's experience within the 9th Grade Academy and the Environmental Science [Envi. Science] micro-communities. These micro-communities are represented in Fig. 4.3. In the

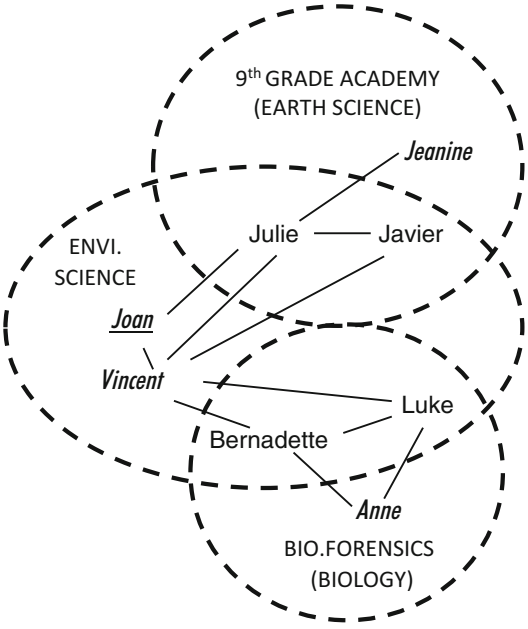

Fig. 4.3 Microcommunities studied

figure, different fonts are used to differentiate the coteachers' status as student teachers, cooperating teachers, or special education cooperating teacher.

The Environmental Science micro-community was an interdisciplinary group of science coteachers (biology, chemistry, earth science, and environmental science) who collectively brought a wide range of resources and experiences into their teaching practice, and strongly supported one another's practice. Coplanning was a mutual process of brainstorming and sharing ideas. As a collective the interns felt that they had a strong voice in the process. Throughout the semester, Vincent (the cooperating teacher) guided the interns, openly shared insights from his classroom experience, and challenged them to ask questions about the effectiveness of the pedagogical approaches they used in instruction (Coplanning meetings, February 17 and April 20).

Within this micro-community, the interns were part of a collective of supportive colleagues who worked together to develop, support and implement instruction. The sense of mutuality and support experienced within this micro-community and in the broader coteaching community of practice, led the interns to value the role of colleagues in supporting one another's practice.

Experiences within the Environmental Science micro-community provided a marked contrast to the 9th Grade Academy micro-community. The coteaching model adapted within the 9th Grade Academy micro-community supported a view of teachers as self-reliant individuals. Coteachers shared resources and decreased their workload when possible by dividing the tasks of planning and preparing for instruction. As a pair Julie and Javier struggled to get along; they welcomed this approach, because it minimalized their need to interact and rely on one another. Jeanine (the cooperating teacher) was generally available to provide advice outside of instruction. With Jeanine out of the classroom during much of the instructional day, there were limited opportunities for Javier and Julie to observe Jeanine's teaching practices, or to teach alongside her and talk about practice as lessons were occurring. This decreased collaboration constricted opportunities for learning from one another in practice.

The multiple coteaching contexts provided student teachers with opportunities to develop multiple frames of reference for their work. As Javier explained, "*I compare, Vincent's class to Jeanine's class a lot, because they are so different*" (Javier Interview, March 16, 2005). Studying participant experience across micro-communities illuminates different ways that the coteachers constructed their roles and participated in the settings. In the micro-communities discussed here coteachers used different models for planning and practice, and collaboration while also fostering student and participant learning.

Analysis of Participation Structures at the Interpersonal Plane

Moving from the community plane of analysis to the interpersonal plane shifts emphasis from cultural practices of the group to verbal interactions and participation structures within specific micro-communities. This level of analysis affords different insight into the learning experiences by enabling researchers to examine

verbal patterns of interaction and meaning-making processes that occur between specific community members. In this section I discuss analysis of the Anatomy and Physiology coteachers' development of a muscle unit. The data set used for this analysis includes all data pertaining to the opening lessons of the muscle unit including: a coplanning meeting, a lunch meeting, classroom instruction, and teacher reflections on the experience. This data set spans the full 4 months of data collection. Data were analyzed using discourse analysis with a focus on semiotics. Specifically, I analyzed teacher talk by first breaking conversation into *episodes of pedagogical reasoning* [EPR] (Horn 2002). Parsing the text by topic affords the creation of EPRs; each time topical emphasis shifts a new episode is created. Each episode was then analyzed to understand the meaning-making processes and participation structures that the coteachers utilized as they worked together.

Within the initial coplanning meeting the coteachers collectively developed plans for instruction and worked to create a unified vision for practice. Through their conversation they proposed and explored nine variations for their opening lessons about the sarcomere—the smallest contracting unit of striated muscle tissue.

Analysis of the coteacher conversations uncovered participation structures that they utilized to support collaborative meaning-making processes and their ability to envision their ideas for practice and examine possibilities for their work. For example, as they planned the coteachers identified over 15 potential pitfalls in their evolving plans. Judith Little and Ilana Horn (2007) have noted that when groups of teachers identify problems in practice other teachers often normalize these problems through comments that suggest that an issue of practice also occurs in their own classroom work. This normalizing practice typically ends conversation and limits opportunities for learning. Using dilemmas as an impetus for collective problem solving is a less common teacher practice.

Problematizing practice was one participation structure that the coteachers in this study utilized to move their thinking about practice forward. Problematizing plans for instruction prompted coteachers to problem-solve and create new plans for practice. In the excerpt below, Sean (student teacher) problematizes the group's plan to have students create models using pipe cleaners. He later builds on Patsy's (cooperating teacher) feedback to generate a solution.

SEAN: Do you think the students will be able to– I would not know how to make the two circles [out of pipe cleaners]. You know what I mean?
PATSY: I don't know. What do you think? Can we give them some directions? Should we give them the idea?

As indicated by Sean's response, which follows Patsy's comments helped him think of possibilities for addressing the problem. Drawing on Patsy's ideas, Sean suggested a way to scaffold the students' experience in order to increase potential for success. His new suggestion also provided a mechanism for teachers to provide further support for students as necessary.

SEAN: We could have them brainstorm it—"How would you build it?" Give them the materials. Say, "Okay, maybe write out a plan of what you are going to do."
PATSY: Uh hmm.
SEAN: And then go over the plans with them—

This exchange provides an example of how the Anatomy and Physiology coteachers worked together to anticipate and proactively solve potential problems of practice, thus collectively reconceptualizing their plans for practice. Throughout the process of coplanning these teachers continued to re-envision their practice and worked to improve their plans. Problematizing and problem-solving enabled the coteachers to further develop and envision their instructional plans for the classroom. These practices were visible across the larger data set of the entire coteaching community, however, the extent to which these things occurred varied by micro-community.

Analysis of Discourse Development at the Personal Plane

Within the teaching profession the notion of teacher as individual is strongly emphasized. This concept is reinforced by the culture of isolation in which individual teachers work independently in their classrooms (Lortie 1975). This study examined the experiences of individuals participating in a model of collective practice. Analysis primarily focused on the collective processes of teaching as a part of a community. However, the notion of teacher as an independent individual was also evident in community member discourse. Teachers spoke about how teachers each have their own teaching style, and the need for preservice teachers to figure out which approaches worked best for them. For example during the final coteaching seminar, Pam, a cooperating teacher and department chair said to the group, "What might work for one of us, isn't [necessarily] going to work for the others—because it's like counter to your own personality." (Seminar, May 10, 2005)

Analysis on the personal plane of development revealed two very different perspectives of identity/ies. One perspective reflected student teacher development of identities as individual teachers. This notion was reflected in both their individual sense of belonging, and in their growing personal perspective of themselves as teachers. Indicative of this development was their growing confidence in their personal abilities. For example, when asked, "What are you learning about your teaching through this experience?" Sean responded:

> That I actually can do it; that I can stand in front of the room and the kids will actually listen to me…. I'm not the oldest looking person…. I learned that it doesn't really matter as long as you project yourself in that way—in that teacher-mode, that's how they're going to see you. (Interview, April 30, 2005)

The student teachers also participated in the activities and practices of the community. Student teachers attended school events, departmental social events, and collectively called themselves, "the posse." Additionally, as discussed earlier, they developed the cultural practices of the community, and through these experiences came to view themselves as members of the science teacher coteaching community.

Research and Methodological Implications

The practicum poses a conundrum. Despite the fact that the practicum is typically viewed by teacher educators as one of the most problematic components of teacher education, practitioners typically identify it as the most valuable aspect of their teacher education program (e.g., McIntyre et al. 1996). Why? Linda Darling-Hammond has written, "Learning to teach…requires that new teachers learn not only to 'think like a teacher' but also to 'act as a teacher'" (Hammond 2006, p. 305). This process of learning to think, act, and feel like a teacher can be understood as part of the process of developing the professional identity of the community. In order for this to occur, preservice teachers must develop the Discourses of community practice and become recognized by themselves and others as members of the community. This multi-planar multi-analytic approach enables us to interpret the experiences of one cohort of secondary science preservice teachers and understand their experiences learning the cultural practices of one community of practice.

The multi-planar analysis illuminates different ways that the coteaching preservice teachers participated in the cultural practices of the coteaching community and were afforded opportunities to become high school science teachers. These analyses expose ways that the student teachers were able to access the Discourses of practice and integrate them into their own practice. Furthermore, this research provides insights into the complex process of learning to participate in a science coteaching community. At the community level we see that the student teachers were integrated into the many different cultural activities and contexts of practice that their cooperating teachers participated in daily. The student teachers learned to move seamlessly between formal and informal contexts within the classroom, the hallway, and the faculty lounge while learning how to interact with students, parents, administrators, cooperating teachers, and other teachers in the school. At the micro-community level, the preservice teachers participated in different constructions of practice according to the group of coteachers with whom they were working. Roles were constructed differently and participants operated in alignment with local practice as they moved between settings. On the interpersonal plane, analysis enables us to see how participants in one micro-community coplanned instruction and utilized participation structures to develop their plans for practice. Finally, analysis of the personal plane illuminates ways that individual student teachers developed both individual and collective identities.

As a composite, the multi-planar analyses illuminate the complexity of learning to teach within coteaching and the situated nature of learning within multiple contexts. Each analytical vantage point illuminates ways that the coteaching experiences reinforced participant beliefs that there is no single "correct" way to practice, but that multiple approaches can be successful or even appropriate in various situations. Historically, the research lens used to study the student teaching experience has focused on classroom instruction. By broadening the research focus to include full teaching days across the 4 months time we are able to glean insight into the cultural

learning and membership development of the student teachers. These findings illustrate a process of development of professional identities and Discourse.

Although this methodology was used to study a coteaching full-practicum model, it would be appropriate for studying other student teaching experiences, and could potentially expand the field's understanding of the process of learning to teach by opening up new research questions and theoretical frameworks for studying the sociocultural learning experience. Findings could also be used to help inform and shape new practicum models. Utilizing this methodology will enable researchers to develop new insights into the complexity of learning to teach. The new understandings that will result could extend current understanding of the process of learning to teach as researchers will be able to gain an understanding of the collective, situated and cultural nature of student teaching experiences and the ways that they impact teacher identity and Discourse development.

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Chapter 5
Video Selection and Microanalysis Approaches in Studies of Urban Science Education

Rowhea Elmesky

> Routine social interaction has proven elusive as researchers attempt to study it. Its moment-by-moment conduct is so complex and nuanced … that information about it can only very imprecisely be derived from interviews or surveys, or from observational checklists, or even from the field notes of participant observers. (Erickson 2006, p. 177)

Educational researchers hold the responsibility of collecting, analyzing and interpreting data in ways that provide insights for answering the research questions at hand. Frederick Erickson, in his chapter in the *Handbook of Complementary Methods in Educational Research*, captures the challenges associated with analyzing interactions in educational settings, and he advocates for the use of audio-visual recordings from which "detailed transcriptions can be prepared and analyzed or careful moment-by-moment coding can be done" (p. 177). In fact, with the ease of digital recording using economically feasible, high quality technology, educational researchers have become increasingly invested in using video data. However, rich reservoirs of audio-visual data often remain largely untapped in research projects due to analysis techniques that fail to capture the micro-complexities of the unfolding, continuous interactions.

Many prominent researchers have been working on developing guidelines for video research. *Doing Qualitative Research*: *Praxis of Methods* (Roth 2005) highlights the benefits of turning one's attention to the micro level. According to Roth, "Microgenetic analysis monitors the minute-to-minute development and change in a person's patterned actions. This form of analysis allows researchers to understand how development and learning result from the interactions under observation" (p. 203). Other publications such as Conducting Video Research in the Learning Sciences: Guidance on Selection, Analysis, Technology, and Ethics bring

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a strong sense of structure to a previously underspecified area (Derry et al. 2010). As these authors point out, video research provides microscopic possibilities to increase the interactional detail that can be obtained, stored permanently, and comprehensively analyzed and reanalyzed. However, despite long strides forward, the specifics for engaging in microanalysis remain somewhat elusive, and hence I seek to add to both the video research literature and to the field of science education by providing a strategic look at video microanalysis as an 'insightful' tool for studying science classrooms. In particular, utilizing one context (an urban high school chemistry classroom), I highlight micro-analytical approaches and methods that have emerged during my work in the area of urban science education and specifically in my studies of marginalized and economically disadvantaged African American youth.

Current State of Science Education

The stark disparities of science achievement as examined across racial and socio-economic lines have been well documented in the literature. These trends have been established at national, regional and local levels. Over one decade ago, in fact, a profound example of the vast achievement difference at the national level was evident in David Berliner's (2001) analysis of international comparative data (TIMSSR[1]). When America's results were separated according to students' race, African Americans ranked at the very bottom. Unfortunately, these dramatic gaps in performance have persisted and continue to be recorded at the state and local levels through high-stakes exam results. A representative case is evident in studying St. Louis and the surrounding cities, where the St. Louis City school district lost accreditation in 2007, and has just recently regained provisional accreditation status. In a St. Louis City school with 98 % black student population, only 8.9 % of fifth graders score "proficient" or "advanced" on the Missouri Assessment Program MAP science exam while, in contrast, 86.7 % of fifth graders score "proficient" or "advanced" in a school in a suburban district of St. Louis that has 91 % white student body.[2]

The effects of such low science performance have also been well researched; we know, for instance, that science serves as a gatekeeper for culturally marginalized and economically disadvantaged students' admission into advanced placements in high school and enrolment in higher education institutions. As these students continue to fail to achieve highly in science, very few have opportunities to pursue careers as scientists, mathematicians or engineers. In addition, scientific understandings help inform social decision-making (e.g., environmental issues) and personal decisions (e.g., health).

[1] Third International Mathematics and Science Study-Repeat.

[2] Interactive Mapping for Educational Data. Tool developed by the Center for Inquiry in Science Teaching and Learning. http://maps.wustl.edu/cistl/mapdata/CISTLmapping/CSDmap.html

Thus, the implications of underperformance on science achievement are grave. With the dilemmas associated with the urban schools, it is easy to become disillusioned and lose hope; and an easy solution for parents and guardians is avoidance or removal of their children from failing educational settings. Thus, it is not surprising that well-resourced parents are able to place their children into the 'better' schools; and less fortunate families either struggle with the restricted options available for their children or choose to fight legal battles to secure other educational options. For example, in July 2010, the Supreme Court of Missouri announced that St. Louis City residents have the right for their children to leave their unaccredited school district to attend county/suburban schools. Following this historical court decision, a preliminary study conducted by Jones (2011) indicated that the number of inner city children who would leave their neighborhood schools for the surrounding districts could potentially be in the thousands. Although this estimate seems high, it represents less than 30 % of the children, leaving 70 % of K-12 students to remain in the failed learning environments of St. Louis city.

As a nation, we cannot forget about the children who continue to be educated in large urban centers like St. Louis where the schools are plagued with abhorrent challenges including science teaching that is reminiscent of what Haberman (1991) describes as the pedagogy of poverty. I argue that educators must be committed to pursuing cutting edge methodological approaches that will shed new light for understanding the learning conditions that are impacting tens of thousands of children stranded in inner city schools. In fact, this article advocates for the strategic and detailed analysis of video for studying science classrooms of schools that are 'failing.' Video allows for the development of rich, thick descriptions of the everyday teaching and learning processes in such environments. If we continue to refine our techniques of understanding what is happening in these spaces, then we can better interrogate the issues of why these events are happening and effectively design and implement interventions based upon informed understandings. Certainly, most would agree that interventions and catalyzing long-lasting change becomes possible when we can better *see* what is happening in classrooms.

Science Classrooms as Communities Rather Than Sites of Power Struggle

In my experiences with inner city schools that cater to majority or entire populations of culturally marginalized and economically disadvantaged children in both Philadelphia and St. Louis, I find that the overarching ideology/schema and human/material resources (Sewell 1992) within schools continuously shape the inherent inequities. While their suburban counterparts are preparing for higher education and being cognitively challenged (e.g., learning about solubility, mineral streak tests, or forces and machines), inner city students from marginalized backgrounds are taught in ways that emphasize behavior control and conformity, defer to more rote forms of instruction (e.g., traditional textbook question/answers and/or worksheet

approaches), and use resources that are less inquiry-oriented. Moreover, many of the teaching approaches utilized in such schools are rooted in the perception that controlling student behavior is key to a successful learning environment, and instructional strategies that are rigid and force compliance are considered the means to that end (Kozol 2006). In some St. Louis City elementary schools, for example, students are routinely disciplined through the removal of their elective (e.g., art) class or by receiving silent lunch and silent PE. Even simple activities such as going to the restroom are highly controlled. In these schools, bathroom breaks are conducted as a whole classroom activity with a large amount of time spent in securing complete obedience and silence in the hallways on the way to and during the bathroom breaks.

Less than 30 min away, students in the surrounding, wealthier districts enjoy the independence of requesting a bathroom pass. These different expectations and associated practices contribute to the development of an inner city school culture where power struggles between students and teachers are a consistent part of daily activities. With behavior modification and control as priorities, teachers engage in pedagogical practices that feel stifling to the students, and some students respond to their truncated agency by exerting resistive behaviors. They may also engage in cultural practices that 'belong' to other spaces (Elmesky and Abraham 2007) and lead to reprimands, isolation, in-school suspensions, and other severe consequences. Successful interaction rituals, solidarity and positive emotional energy (EE) (Collins 2004) are sparse in inner city classrooms. Hence, students and teachers feel alienated from one another (e.g., Seiler and Elmesky 2007), and a sense of classroom community is missing from the inner city science education experience. Unfortunately, in fact, failed interactions and divisive feelings in the classroom emerge due to the cultural, racial, gender, age, and socioeconomic divides that are typical of urban settings. That is, teachers are generally very different from their students, and in many cases, are unaware of how to reach their students in meaningful ways—they do not know how to make the subject matter accessible across these sociocultural divides (e.g., Barton 2001; Tobin 2006; Tobin et al. 2005).

In this chapter I focus on a tenth grade chemistry classroom inner city context (City High) with an immigrant teacher from India (Anita). Her experiences within the school revealed that the majority of her students felt disconnected from her as well as from the subject matter of science. In her autobiographical reflections she wrote,

> Eventually I realized that, when working with a group of students who did not identify with or feel motivated about learning science, there should be some kind of relationship between the student and the teacher, especially when the teacher is from a different cultural background. The greatest challenge that I faced was to be accepted by them as their teacher. (Abraham 2007)

With her classroom as a backdrop, this article argues for the usefulness of video microanalysis to better understand the intricate details of classroom interactions in ways that might illuminate sociocultural building blocks that are essential to successful science learning communities.

Peering into the Chemistry Classroom Window

> I think that the labs are the best part of this chemistry class. We have fun with it. I think we get a better explanation by seeing and doing these labs instead of a lecture. Yes I think we have grown as little scientist[s]. We look more familiar within videos with the equipment. Everyone seems to enjoy the lab. We all like to work in groups. (Sasin, Journal entry reflecting on lab activities, 3/30/02)

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> I really enjoyed doing the labs. They are very fun and, at the same time, I learn valuable lessons in chemistry. … Sometimes when I come to chemistry class, for some reason, I don't feel like working and the work Ms. Abraham go over can be boring at times. But when it is time to go to the lab room, my interest in the class began to spark up because the labs are my favorite part of the class and they are good teaching aids. (Mike, Journal entry, 3/13/02)

The students attending City High suffered from circumstances of pervasive poverty (80 % of the students received free or reduced lunch) and from continual de facto educational segregation (99 % of the students were Black). As seen in other comprehensive high schools, the school was divided into seven Small Learning Communities (or SLC, a school within a school) based on different themes. The entire school was on a block schedule (90 min per class), and Anita's class met once a day for 90-min periods for 5 months during the second semester of the school year. This study took place in the SLC called Business Academy, an academy where more importance was given to developing computer and accounting skills than to science. Business Academy students like Mike and Sasin were, on average, low performers and characterized by the administration and teachers as having behavioral and emotional problems—her class consisted of a student body typically perceived as unmotivated, unreachable and at risk for dropping out of high school.

The above journal excerpts, written 2 months after the semester began, capture some of the emotions that were present as students engaged in the laboratory activities in Anita's classroom. Evident in the entries, overall, the labs captivated the students' attention and helped facilitate the development of positive feelings about chemistry. The optimistic tone of the students' reflections is quite significant especially in an urban high school where students have had countless negative schooling experiences. Mike used language like "fun," "enjoy," and "exciting" and described the laboratory time as "my favorite part of class" and "good teaching aids." The excerpts also indicate that the students were beginning to identify themselves within a larger narrative of science (e.g., "we have grown as little scientists"). Certainly, the students' perspectives of the laboratory activities being the "best part of this chemistry class" are quite remarkable, and urge one to try to understand why these positive emotions might have existed. Here video microanalysis becomes key.

Although video can be reviewed and investigated inductively with broad, general questions in mind and without a strong orienting theory (Derry et al. 2010), this chapter shares micro-analytical techniques within a deductive framework. That is, I focus on modeling how video analysis looks when guided by (1) specific research

questions that shaped the data selection process, and (2) particular theoretical orientations. Within these deductive guidelines and with techniques such as fluctuating speeds (speeding up and slowing down to frame-by-frame viewing), I use actual examples from this research to illustrate methods for identifying unconscious patterns and contradictions and for providing micro-attention to eye gaze, body orientation and gestures.

Anita's overarching research questions were to: (1) understand how a teacher can earn respect and build rapport with her students, and (2) understand how a teacher can connect the teaching and learning of science with her students' "cultural capital" (Bourdieu 1986) so as to make science learning more meaningful to them. Moreover, in accordance with an emergent qualitative research design, over the duration of the study, additional research questions arose that centered upon understanding student-student interactions, and particularly group work in the laboratory. As a result, I present a detailed microanalysis of one teacher-student vignette and the interactions within one student group.

Theoretical Framework

The video microanalysis of Anita's chemistry classroom footage is conducted with reference to theoretical lenses focused on understanding identity and emotions in the classroom. Students' identities are understood as being formed and (re)formed within the larger collectives—in this case the classroom and the chemistry lab. Further, the making and (re)making of identity is viewed as a recursive process in which the individual constantly navigates between defining him/herself and the definitions attributed to him/her by others (Roth et al. 2004). Therefore, in science classrooms, a student's 'science-learner' identity could be understood as being constantly made and re-made through interactions with peers and with the teacher.

In addition to this construct of identity, interaction ritual (IR) theory (Collins 2004) became an essential theoretical tool for analyzing the video. IR theory calls for attention to be given to those ingredients that contribute to successful (positive) interactions in the chemistry classroom and ultimately foster solidarity or a strong sense of group cohesion and affinity among the members. The video microanalysis drew upon Randall Collins' sociology of emotions to identify successful interactions of the teacher with student(s) and student(s) with student(s)–which are recognizable by synchrony or fluidity as the participants anticipate and react 'in time' to one another. According to IR, successful interactions are marked by the presence of a shared focus amongst the group members. This shared focus can be multifaceted and include objects, persons, or activities. When shared, as the focus changes during interactions, group members visibly make the shift to the new focus together. Accordingly, as group members become increasingly aware of each other's direction(s) of attention, they also come to share a common emotional experience or mood. Collins (2004, p. 48) explains, "As individuals become more aware of what each other is doing and feeling, and more aware of each other's awareness, they

experience their shared emotion more intensely, as it comes to dominate their awareness." Awareness of another individual's focus and sharing an emotional orientation is crucial in determining whether interactions are successful and whether bonds of solidarity and emotional energy (or feelings of empowerment, confidence, and initiative toward action) are emerging. Therefore, video microanalysis techniques, guided by interaction ritual theory, allows for the identification of: (1) general patterns of engagement in interactions; (2) specific points of mutual focus and the group members' attraction to these points; and (3) indicators of physical and emotional entrainment in the form of synchronous movement and spontaneously coordinated expressions of emotion. Importantly, these microanalyses ultimately contribute to forming 'big picture' interpretations regarding solidarity and emotional energy.

Studying Teacher-Student Interactions

Getting Started: The Role of Research Questions and Theory

Guided by sociocultural theory and by Anita's research questions focused upon understanding how she could better connect with her students, the video microanalysis process began by narrowing down the available footage to a selection of those segments that seemed to address the question(s) on hand and to correspond with our theoretical outlook. Anita and I began reviewing large quantities of video spanning across the semester, with the primary purpose of studying both the interactions between Anita and her students and the interactions between peers. Even though there were videotapes of both the 'lecture' and 'lab' portions of Anita's classes, in the laboratory context, interactions were more fluid and conducive to study. In addition, evident in the students' commentary, above, the lab space seemed to be of high interest to them as well. Therefore, our first level of review involved the selection of the video footage of the students engaged in labs. Predominantly, this footage had been recorded within a separate chemistry lab space (outside of Anita's regular classroom). We began reviewing this lab footage to identify patterned actions, as well as contradictions to those patterns, in the interactions observed. During the review of video, preliminary selection analysis required alternating between fore-fronting teacher-student interactions and fore-fronting student-student interactions. In both cases, once the selection of vignettes occurred, micro attention intensified as we tried to understand the subtleties of what was occurring.

Identifying Teacher-Student Patterns: Anita's Physical Proximity to Students

As we began to select vignettes of Anita's interactions with her students, it became clear that she engaged in interesting patterned actions, which were largely unconscious in nature. Much to her own surprise, she found that she regularly utilized

physical closeness and gestures such as pats on students' hands and arms as well as leaning her body into the students' working spaces while helping them with their labs. Some still frames of these actions are in Fig. 5.1.

Manipulating/Fluctuating Speeds: Making the Unconscious, Conscious

In one particular video, Anita was shocked by her unconscious proximity practices that were evident upon observing her interactions with a student, Stevenson, who wasn't sure about the results of the reaction between the copper sulfate and aluminum foil during a Physical Change and Chemical Change Laboratory Activity. After watching the video of this interaction in real time, we began to become attuned to some very unconscious interaction patterns in which Anita was engaging. In order to obtain a better sense of the patterns, we expanded beyond normal real-time viewing practices. We utilized techniques like watching footage again at different speeds - in both fast-forward and slow motion modes - to help highlight aspects of the video that might be otherwise overlooked. In fact, manipulating the playing speed allows aspects of the video to leap to the foreground and other aspects to fade

Fig. 5.1 Anita in close physical proximity with students as they complete labs

into the background. Frame by frame progression through this video vignette revealed that Anita kept physically in contact with Stevenson for about 40 % of the interaction time or a total of 30 s out of 73 s. Her connections with Stevenson ranged from lightly placing her hand on his shoulder, over his forearm, on top of his hand, and eventually holding onto his finger and pen. Table 5.1, provides a micro-analytical look at the interaction between Anita and Stevenson.

The table chronologically captures frames that illustrate Anita's physical proximity to Stevenson. Guided by the research question related to her relationship with the students, our attention necessarily gravitated to the interesting forms of contact taking place between the teacher and student. The other students in the room faded into the background so much so that even when Anita (in the video) became distracted away from Stevenson's paper by their loud noise, our analysis remained focused upon what Anita was doing to stay connected with Stevenson during the interruption. We noted Anita's body level and direction relative to Stevenson. We watched for eye gaze and whether there was a common focus upon items (e.g., papers, test tube, pen). We attended to whether there was entrainment between the teacher and student; for example, they were in tune with each other's movements, and we found that 'the dance' of the pencil between them was in sync, unconscious, and yet anticipatory.

By utilizing the technique of fluctuating the playback speed, this interaction brought to light important patterns in Anita's ways of being with her students in her classroom. Importantly, prior to engaging in this analysis, she was not aware of the existence of such patterns, nor was she aware of how she utilized space and proximity to accomplish her objectives as a teacher. Moreover by slowing down the interaction, through the lens of IR theory, Anita came to understand how her unconscious practices acted as resources. Her physical proximity to Stevenson, and specifically her hand motion, served as a point of mutual focus for both of them. Stevenson's entrainment in her movements was clear in the manner by which his head turned and his eye gaze followed along as she explained. Therefore, the analysis seems to point to the emergence of a successful interaction that could ultimately produce or (re)produce solidarity/connections between Anita and Stevenson. This finding was confirmed through other forms of data (e.g., interview transcriptions) that were used to triangulate with the video microanalysis data. For example, during a student researcher meeting, Stevenson and I watched this particular video vignette interaction together, and our subsequent conversation provided an important layer of insight by including the direct perspective of the student involved.

Rowhea:

Another thing just from a research point of view, like when I look at the [video] clip, the thing that really stood out to me is that you guys exchanged the pencils. It goes back and forth with each other. Like I don't know if you noticed how she takes it from your hand and you take it from her hand… a lot of kids would kind of get ticked off if a teacher took their pencil out of their hand. Also, you know like, if a teacher like puts a hand on them, and you know they are like "Don't touch me okay!" So the thing that stood out to me is you were kind of pretty cool with her taking the pencil.

Table 5.1 Frame by frame capture of Anita and Stevenson's interaction

11:25:51	Anita walked toward Stevenson. As she reached him, Anita put her left hand on his paper and her right hand on his shoulder. She looked to where he was pointing (at his laboratory procedure)	
11:25:56	Anita picked up the test tube from the rack using her left hand and simultaneously brought her right hand down on Stevenson's arm. She bent down a little bit and was at the same level with him	
11:26:00	Using his pen, Stevenson started to show Anita the instructions and his write-up. She remained slightly bent, with eye gaze intent upon his paper	
11:26:03	Anita took her right hand off of Stevenson's arm, and used it to bring the test tube upward to his eye level. She gestured and pointed toward the bottom of the test tube, as she spoke	

(continued)

Table 5.1 (continued)

11:26:09	Stevenson started writing his observations in the data table. Anita watched closely, slightly bent and with the test tube in her left hand. Her right hand slowly came down to take the pen from Stevenson's hand	
11:26:11	There was a loud noise; simultaneously Anita stood up, and her hand froze on top of Stevenson	
11:26:12	Anita turned around to talk to the students in front (who were making noise) while still making physical contact with Stevenson by holding onto his hand and the pen	
11:26:19	Anita turned sideways and strained to look at the students making noise. During that process, she let go of both Stevenson's hand and pen, but her hand with fingers spread remained on top of Stevenson's hand	

(continued)

Table 5.1 (continued)

11:26:22	Anita moved her hand off of Stevenson's hand and onto his lower arm. Stevenson does not move away	

Stevenson:

The reason why, ya mean [you know what I mean], I didn't react in a certain way [was] because she was showing me how to do it and she wasn't showing me nothing wrong. She wasn't trying to hurt me or nothing. She was trying to show me something. Somebody is trying to show me something. I would listen to her.

Rowhea:

Do you think physical contact with the student when you are explaining something—like give a pat on the back or stuff like that—do you think it is positive or negative?

Stevenson:

I think it is positive cuz [because] she is showing that she really cares. If she didn't then she would just say go ahead and do whatever and she would roll out. But Ms. Abraham explained it to me. It seemed like she cared.

Evident in the verbal exchange and as might have been expected from his actions in the video, Stevenson's reaction to Anita was positive. He interpreted Anita's presence as caring, and preferable to an alternative scenario where she might have left him too quickly (i.e., "she would roll out"). His verbal acknowledgement supports the video microanalysis findings that did not reveal an adverse reaction from Stevenson. However, microanalysis of other video footage from the lab setting reveals that student acceptance or passivity to Anita's physical proximity was not always the case. For example, a different student (Dana) enacted contradictory practices when Anita was working with her to read a triple beam balance.

Contrary to Stevenson, Dana moved away from Anita upon becoming conscious of her teacher's close proximity. Interestingly, the video shows that Anita did not even realize that Dana backed away from the space they were sharing, and Anita maintained her physical position while continuing to focus on showing Dana how to read the scale. As Anita continued in her explanation without any acknowledgement of Dana's motion, the video analysis reveals that Dana was able to re-engage her attention to the task at hand. Within a few seconds, Dana relaxed her recoiled stance and moved in closer to Anita. Thus, although there was a slight deterrence midway through the interaction, Dana and Anita ultimately experienced a somewhat successful interaction with the triple beam balance as their point of mutual focus,

with entrainment emerging around the activity of learning how to read the measurements, and with a shared mood of seriousness upon the task at hand that increased in intensity over time (Table 5.2).

Closely examining teacher-student interactions in the light of particular theoretical frameworks, I argue, leads to developing complex, thought-provoking findings in relation to research question(s) at hand. The earlier analysis of Stevenson and Anita reveals a noteworthy pattern of Anita in her interactions that she unconsciously enacted and the second vignette—through the very different reaction of her student—brings further to light Anita's lack of awareness of her practices related to proximity with her students. In both cases, Anita was intent upon the subject area and her explanations (i.e., student learning) to the extent that she was unaware of her "invasion" of the students' space. The second vignette further reveals the complexity of educational research and the importance of not reducing understanding to a single line of reasoning that is conclusive (i.e., teachers should be in close physical proximity with students to improve their relationships in the classroom). That is, the video microanalysis of this data reveals that students are different and much of what takes place in the classroom is in the moment and unfolding rapidly in manners that are unconscious. The second vignette also points to the fact that even though the interaction was ultimately 'successful,' if practices don't 'feel' right for a student, their entrainment in the science content can become disturbed (e.g., Dana pulls away from Anita). Thus, teachers must not only work to be aware of their patterns in interactions with students, but also recognize that students will interpret their practices differently.

Zooming Back Out

In conducting video microanalysis, it is important not to become trapped in a narrow, one-way alley of analyses that only involve peering through a pinhole in a fence. That is, while microanalysis allows for the concentrated study of subtle aspects of science-learning environments, as researchers, we should remain committed to understanding these micro findings within the larger context. Thus, it is often important to situate microanalysis of interactions within an understanding of the histories of those involved (Goldman and McDermott 2009). In the case of Stevenson and Anita, Stevenson's past experiences are important to understanding the significance of what was occurring and why he might have responded to Anita's proximity in the positive way that he did. As he explains in the interview excerpt below, Stevenson had grown up in an environment where his father cared for him. When his father passed away, Stevenson had to not only depend upon himself but also take care of his previously absent mother. He explained this situation to his peers in an interview:

> *Me—I depend on myself. I buy everything I have. I pay for my food, my clothes. I pay bills. I pay everything. I don't depend on my mother. I do everything. I'm suppose to do everything—that [what] a man would do. Me—myself how most people mothers are, that's how my father was. My father took care of me ever since I was born; my mother was gone.*

Table 5.2 Frame by frame capture of Anita and Dana in close proximity

	
Anita watches at close proximity as Dana attempts to measure the correct mass of baking soda	Dana turns to Anita as she demonstrates the use of the scale
	
Anita leans in toward Dana. Dana remains in her position	Dana turns toward Anita and notices her close proximity
	
Dana's whole body recoils away from Anita, leaving a large gap between them	Anita remains in close proximity and Dana remains pulled back away from her

(continued)

Table 5.2 (continued)

	
Anita reaches in with one arm. Dana continues to pull away.	Dana leans towards Anita slightly, and follows along where she points.

My mother left me when I was about three months. So my father took care of me all my life, and he was the most important thing to me. I don't have nobody now because my father died when I was thirteen. Ya-mean [you know what I mean]? I look up to myself cause I take care of myself and I do everything I'm suppose to—like my father did. So I don't really look up to nobody but myself. And then after I lost my father, I was just like turned over. That's how I felt. I ain't care about nobody. Even though I'm taking care of my mom now and everything, I don't consider her like my father because she wasn't there for me. Ya-mean? That's crazy I ain't never heard of that before—for a mother not to be there for their child. I heard of a father but not a mother. My mom was heavy heroine user and a crack addict—did it all. Naw, my mom ain't better. So if she was to change, you still wouldn't look up to her. I still love her and care about her I just don't have… I don't you know…that love. I care for her cuz [because] she birth me, but then I don't care. I feel as though I can't love somebody that's never [been] there for me. (February 2002)

These powerful reflections by Stevenson communicate the importance of the themes of "care" and "love" in his relationships with others. Further, his commentary clearly indicates his conscious categorization of individuals as 'those who care about him' and 'those who he cares about.' Since the boundaries between school, home, and neighborhood are porous (Elmesky and Abraham 2007), it is to be expected that values and ideas around relationships outside of school will seep inside the classroom and impact the relationships that emerge between teacher and student(s). Moreover, video microanalysis of just a few minutes of interaction time illustrates the enormous possibilities of understanding what may be important to students. In inner city classroom environments where teachers like Anita are trying to be more culturally attuned and connected with her students, it is important to have these methods for capturing and studying unconscious actions that unfold. Certainly, we cannot underestimate the long-term impact on teaching and learning practices when teachers and students become more aware about how their actions can communicate caring and respect.

Studying Student-Student Interactions

Micro-level Contributors to Solidarity

With a theoretical framework for studying cohesiveness/solidarity that strengthens over a period of time, Anita and I also reviewed the chemistry lab footage to learn about the different group dynamics that were emerging as the students followed directions, utilized new equipment like Bunsen burners and triple beam balances, engaged in unfamiliar procedures, and developed roles and a division of labor to complete the assigned tasks. We were interested in identifying students who appeared to work together in a manner that was supportive and operated according to a shared division of labor as well as those groups that seemed to be more loosely bound and did not assist one another. Since we recognized that within all contexts there are thin patterns of coherence (Sewell 1999), we expected that even groups whom we identified as cohesive and exhibiting solidarity might also sometimes engage with one another in less unified ways. One group in particular caught our attention—an all-female laboratory group consisting of Shaneta, Tosha, Agnus and Ann.

In the remaining portion of this chapter, I share video microanalysis around this group's completion of a Flame Test Laboratory Activity. The students were responsible for identifying different elements based upon the color(s) produced when they were placed within a Bunsen burner flame. After observing and recording the flame color results for six known compounds, students were expected to identify the unknown metals in the given compounds. Below, I provide a description of the group's initial engagement with the lab, as the video footage was re-viewed on regular playback speed.

> *At the start of the laboratory activity, Tosha and Ann were sitting on opposite ends of the laboratory table with Shaneta and Agnus in between them. Anita reminded them of the laboratory safety rules. "No, you didn't do something yet," she called out. "Goggles!" Tosha exclaimed as she left to get goggles for her group. "Oh, your goggles," Shaneta echoed. Agnus took a rubber band off her wrist and tied back her hair. "I better put my hair back before this fire burn it off," she remarked to her group. "Tosh, get me some, get me some clear [unscratched] ones," she told Tosha. When Tosha returned to her group, she distributed the goggles to each group member. As Tosha and Agnus placed the goggles on their faces, it was as if a change overcame them. Their backs straightened, they pushed back their hair and held their heads a little higher. Ann watched the others place their goggles on, but continued to hold her goggles in hand. She started to jiggle her shoulders. Immediately, as if by default, Agnus and Tosha's shoulders also began to move to some unheard beat. Because Shaneta was not visible to the camera at that moment, only her hands were visible, and they were also moving with the beat. Ann, now with her group's attention and still holding her goggles in hand, recounted the TV show she had watched and began to sing, "Scooby Dooby Doo, where are you?" The rest of the girls joined her in perfect harmony, completing the phrase in unison, "Got some work to do now!"*

In this laboratory activity, real time viewing of the video footage seemed to indicate that the girls had some level of rapport in their small group setting. Compared to the analysis of previous labs from earlier in the semester, where the interactions between

members had been few and limited, the group's interactions in the flame lab indicated an emergence of group solidarity among the group members. Guided by interaction ritual theory, we decided to take a closer look and focused on identifying the ingredients for group interactions—(1) bodily presence, (2) point(s) of mutual focus, (3) shared mood, and (4) the existence of entrainment. Physically arranged around their lab table, it was clear that mutual focus began to emerge around their common knowledge of a cartoon song, and evidence of shared mood and the beginnings of entrainment appeared through Tosha, Agnus and Shaneta completing the song phrase in perfect harmony with Ann. By manipulating the playing speed while studying the group's practices as a collective, frame-by-frame analyses revealed that these beginning seeds of mutual focus and entrainment persisted over the class period, and contributed to chains of successful interactions between the young women.

A Closer Look

As the lab began to unfold, the main point of mutual focus throughout the activity was predominantly the Bunsen burner. Since the group's actions were centered on placing a compound into the flame and then observing and recording the color that emerged, we analyzed the video footage for evidence of group entrainment in the form of similar body orientations and common direction of eye gaze while they worked. As they engaged in turn taking with the burner, a rhythmic-like routine was established and their focus upon the activity strengthened and persisted. Furthermore, the interactions were distinguishable by the intense and shared mood of seriousness and aesthetic awe over the colors produced. For example, frame by frame review of the footage when Agnus was placing barium chloride into the flame, revealed group members oriented and focused with their eyes and bodies toward Agnus and the Bunsen burner. Shaneta used her left hand to nudge Agnus' right hand toward the flame. Once the compound was inside, she exclaimed with a smile, "Ooohhh, mine pretty!" while Shaneta simultaneously declared loudly, "OK that's enough."—perhaps concerned that the burned barium chloride would fall on the Bunsen burner (Table 5.3).

While the peers were entrained with one another's actions throughout the lab, a pattern appeared in which Shaneta acted as a guide. She engaged this role by making the scientific tools accessible to others—physically relocating tools and nudging equipment forward to the other group members. Most pronounced, however, was the manner by which she physically guided the others' hands as they placed their compounds into the flame, and also gently pulled back to communicate to each girl that her turn had come to an end. While Shaneta would leave her own stick in the flame for an average of 10 s, she would only wait about 4 s before getting involved in another member's turn. The young women allowed her interference without noticeable irritation. Interestingly, this practice did not seem to break their concentration or disturb the student who was taking her turn. Instead,

Table 5.3 Mutual focus, entrainment and emergent group solidarity

	
From right: Tosha, Shaneta, Agnus, and Ann. Shaneta nudges Agnus' right hand toward the flame. Entrainment in the lab is evident in their focused eye gaze and body orientations. The mood is initially serious and tense	Shaneta helps Ann hold her stick in the 'right' spot above the flame. Agnus' face reveals the shared mood of excitement that unfolds as the peers enjoy the different colors that emerged from the flame

Two seconds after Agnus placed her compound into the flame, Shaneta reached in to pull her away. Agnus pulled back playfully. Entrainment remained as they played tug of war. "Wait, yo! Wait yo!" Agnus said. Similar expressions on their faces indicate that this was not a failed exchange.

Fig. 5.2 Contradiction in the thinly coherent interaction pattern

it appeared to become an integrated and unconscious part of their lab procedures, allowing a rhythm of moving in and moving out of the flame to arise. However, as with any pattern, contradictions did occur. On one occasion, when Shaneta tugged Agnus' arm to take the compound out of the flame after only 2 s had passed, Agnus resisted, saying, "Wait-yo! Wait-yo!" Although the synchrony and fluidity of the rhythm that had developed was interrupted, it was only temporary. The young women both remained entrained on the flame and the mood stayed positive, overall (Fig. 5.2).

Zooming Back Out

Although not discussed in detail here, video data from the remaining laboratory activities during the semester also show a thinly coherent pattern of successful interactions between Shaneta, Agnus, Ann, and Tosha. In one of the last labs of the semester, the Starch-Iodine Clock Reaction lab, successful interactions were clearly present for the group and especially evident between Tosha and Shaneta. For example, when it was time to add the starch and iodide, they coordinated their actions as Tosha gave Shaneta a verbal signal, "Ready, set, go!" Their entrainment intensified to the extent that their actions mirrored each other. As Tosha stood up from her seat to join Shaneta in getting a closer look at the results, their heads bent downward in an identical manner, almost touching, as if in a football huddle.

The microanalysis of this particular group's engagement in chemistry lab highlights the importance of having rigorous methods that lead educational researchers to understand the 'glue' that holds together groups of students and to understand how individuals form perceptions about themselves as science learners. The power of video microanalysis is in looking at the short-term instances of social interaction with an understanding of how this impacts future possibilities for a science learner. Feelings of empowerment, confidence and initiative that emerge from successful interactions in a science lab has the potential to ultimately lead these young women to possess long term positive associations with chemistry symbols, such as canonical language and ideas, scientific texts, materials, and equipment.

By focusing on identifying micro moments of entrainment and synchrony, educators are able to gain a better idea about solidarity and group dynamics, and hence determine why some student units are more unified and successful in collaborating. Moreover, the combination of video microanalysis methods, theory and research questions help researchers to better 'see' urban science classrooms that are written off as failing. In the case of Anita's classroom, we were able to consider how students, who were expected to be disengaged and unmotivated in chemistry class, might in fact, be able to develop positive identities or storylines of self in association with the science discipline—if we can pay closer attention to ensuring they experience positive interactions with teachers and their peers.

The Final Word

In highlighting analytical video microanalysis methods through examples from of one classroom, I make a case for carving out a distinct space and role for microanalysis within the realm of science education. In fact, I argue that it is essential for science education studies to engage the most rigorous techniques possible to understand how teacher-to-student interactions and student-to-student interactions can facilitate the production of solidarity and positive emotional energy. Video can and should have a central role in helping us better understand science classrooms as

spaces where successful experiences serve as tremendous forces for improving urban science teaching and learning contexts. That is, video microanalysis is a crucial tool for linking emotion and cognition within science classrooms. By studying the minute details of interactions, researchers can learn to recognize the integral components that contribute to or detract from teachers and students or peer groups working together in ways that facilitate maximal cognitive growth. In large urban centers like Philadelphia and St. Louis, where thousands of students are 'written off' year after year, it is imperative that researchers take the time to look closely at what is occurring in classrooms and schools that are 'failing' according to testing standards. We have to recognize that the big picture improvements of school districts begins by linking back into the micro level - by understanding what can make schooling, and science classrooms more specifically, more meaningful spaces for students whom are most marginalized by our society.

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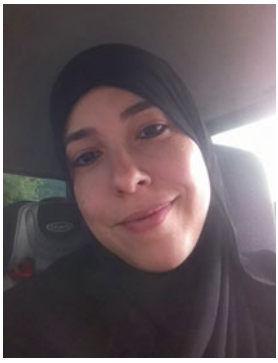

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Chapter 6
Equity, Ethics and Engagement: Principles for Quality Formative Assessment in Primary Science Classrooms

Bronwen Cowie

The purpose of this chapter is to offer a set of principles that can be used to guide the conduct of classroom assessment when learning is viewed as the transformation of identity (Wenger 1999) and priority is given to the role of assessment in enhancing learning (formative assessment). Validity and reliability have traditionally been considered the cornerstones of quality in assessment. However, these criteria were developed in the context of testing to select students for limited opportunities and when learning was viewed largely as an acquisition of knowledge. Matters to do with equity, ethics and student engagement become salient as criteria for judging the quality of assessment when learning is viewed from a sociocultural orientation, particularly in the case of classroom assessment. As principles, these considerations take account of the situated nature of any evidence of learning and of the possibilities for, and impacts of, actions based on this evidence. By seeking to maximize the benefits, and minimize the potential harm, of assessment they acknowledge that knowing, learning and social relations entail each other. In short, they aim to optimize the role that classroom assessment can play in productive student learning and identity development. I conclude the chapter with a discussion of the implications this broader conception of quality in assessment has for teachers and students.

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A Sociocultural Framing of Formative Assessment and Validity Concerns

Formative assessment, also known as assessment for learning, is a process that involves teachers and students recognizing and responding to student learning, during that learning (Cowie and Bell 1999). Since Paul Black and Dylan Wiliam (1998) demonstrated the potential of formative assessment to enhance student learning assessment for this purpose has been a focus for policy and practice, although teachers are still obliged to sum up and account for student learning to stakeholders outside the classroom. Validity theory in formative assessment places emphasis on how effectively the assessment process works to improve learning with threats to validity being those things that get in the way of improvement (Stobart 2008).

The formative assessment strategies that are commonly recommended to teachers are: student self- and peer-assessment, teachers communicating clearly to students their intentions for student learning and the criteria to be used to judge the success of this learning. Feedback to help students to close the 'gap' between their current understanding and the desired performance is the most crucial aspect of formative assessment (Sadler 1998). However, the ultimate goal of formative assessment is for students to become autonomous learners who actively monitor their own understandings and take action to enhance them.

Classroom research suggests that many teachers find the implementation of formative assessment challenging because involving students in the assessment process disrupts traditional teacher-student power relations (Gipps 2002). Even when teachers use recommended strategies they do not always achieve shifts in student dispositions to proactively engage in learning and assessment. To explain this situation Bethan Marshall and Mary Jane Drummond (2006) distinguished between the letter and the spirit of formative assessment. Teaching to the letter involves the use of strategies whereas teaching to the spirit also requires that teachers value learner autonomy, view the classroom as a site for their learning about students and interact to create a classroom environment in which learning is socially constructed. Sociocultural views of learning have much to offer in addressing the challenges inherent in this.

A sociocultural perspective changes the way important concepts within formative assessment are understood and subsequently how its quality might be judged. From a sociocultural perspective, learning involves the interaction of learners and the resources in their environment (people, language, physical tools, routines and so on) rather than an individual acquisition of knowledge. Identity is highly significant because "learning transforms who we are and what we can do, it is an experience of identity" (Wenger 1999, p. 215). A sociocultural view of learning, therefore, directs attention to "what kinds of personal identity and cultural values our science teaching accepts, respects, or is compatible with" (Lemke 2001, p. 300). This is also the case for assessment because, as Caroline Gipps (1999) has pointed out, classroom assessment plays a pivotal role in shaping student identity:

> Because of the public nature of much questioning and feedback, and the power dynamic in the teacher-student relationship, assessment plays a key role in identity formation. The language of assessment and evaluation is one of the defining elements through which young persons form their identity, for school purposes at least. The role of assessment as a social process has to be acknowledged in this sphere: Identity is socially bestowed, socially sustained, and socially transformed (Berger 1963).

More than this, a sociocultural orientation acknowledges that classroom assessment plays a pivotal role in the local construction of what counts as knowledge, what it means to learn and who can have authoritative knowledge (Moss et al. 2006). Jay Lemke (2001) argues that understanding learning as a social process with social consequences for students' lives, both in and out of the classroom, may explain why some students do not engage with school science - they experience a conflict between the identities that are available to them in science classrooms and the identities that are meaningful elsewhere.

From a sociocultural perspective there is no point looking within the student for their learning, as might be the goal from within a cognitive constructivist frame. Evidence of learning is anchored to the context of its generation, and so are possibilities for action. Students perform their science selves when they take up, resist, and/or transform normative scientific practices and identities through their use of physical tools, representational means and talk (Carlone et al. 2008). That is, students enact their science identities through the way they talk, think, use tools, value and interact in ways that render who they are and what they are doing as recognizable to others (Gee 2001). Seen this way, assessment practices are simply patterns of participation that contribute to the development of students' expertise as members of a community and to their identities as knowers, learners and users of this expertise (Cowie 2005). This means that feedback involves more than information about student conceptual learning – its affective, social-relational and cognitive aspects and impacts are inextricably intertwined. Student questions become an important source of insight into their self-monitoring. Student self-monitoring is evidenced through when, where and how students recognize and make use of resources and opportunities to develop their expertise rather than teacher evaluative actions.

The Imperatives and Affordances of Science and Science Education

Validity theory includes a concern for the extent to which an assessment task samples a domain or discipline (Stobart 2008). Given that what is not assessed is generally rendered invisible within the enacted curriculum (Moss 1994) the quality of formative assessment depends on whether it attends, over time, to all aspects of a discipline. Current conceptualizations of science mean that quality assessment needs to ensure students experience science as a material practice, a social practice and a rhetorical practice (Ford and Forman 2006). Put another way, students need to

experience the practice of science and what it means to be constructors, presenters and critics of science knowledge claims (Duschl 2008). What a sociocultural orientation brings to the fore, in considering science as the domain for assessment, and what is not often considered in discussions of quality assessment, is whether, and in what ways, the norms and practices of science/science education afford students and teachers agency within the assessment process. Current conceptualizations of science and science education, as detailed above, seem to offer some rich opportunities for student agency. All the more so when, in New Zealand, as elsewhere, schools are charged with developing students as "life long learners who are confident and creative, connected and actively involved" (Ministry of Education 2007).

Principles for Assessment as a Sociocultural Activity

So what does this mean for how we might conceptualize and practice quality informative assessment in the primary science classroom? In answering this question I was influenced by student comments and actions. They appeared eager to garner the benefits of interactions that were genuinely formative but their enthusiasm for interaction was tempered by past experiences of harm to their reputations and sense of self, arising from teacher and peer comments and actions. Thus, the principles I propose aim to maximize the benefits and minimize the harm of assessment interactions. In brief then, quality formative assessment needs to create a learning environment that embodies the following three principles:

- an ethic of care in which harm is minimized through respectful relationships;
- a concern for equity so that all students have access to the potential benefits of formative assessment; and
- active student engagement in a process of conceptual agency that involves the interplay of student authorative and accountable positioning.

The three principles are illustrated with vignettes taken from the classroom-based work I have undertaken with colleagues as part of the LISP (Assessment) study (Bell and Cowie 2001); the Classroom InSiTE study (Cowie et al. 2013); the Quality Teaching Research and Development project (QTR&D) (Glynn et al. 2010); and Culturally responsive pedagogy and assessment project (CRP&A) (Cowie et al. 2011).

Do No Harm – The Ethical Principle

From a student perspective, the first imperative is that classroom assessment does no harm. The principle of no harm is a student response to their experience of the unpredictability of teachers' assessment purposes and responses when assessment is a public practice that can construe them as competent, or not. Students recognize that teacher assessment purposes can range from seeking out information for

genuinely formative purposes to summing up and reporting on their learning to others, and onto monitoring and managing their behavior. The difficulty for students is that a teacher's purpose is only revealed to students through his or her response to their actions and this response could either benefit or harm their identities and expertise as learners and knowers. Teacher body language, in addition to, or as an alternative to their comments, could signal a student has asked a perceptive question or that they are "slow" or "dumb," thereby diminishing the student's sense of self as well as their relations with peers. Peers could even respond negatively to a positive teacher response if they construed a student as a "try-hard" or "crawler." Expectations of potential harm arising from teacher actions appeared to be of long standing as the LISP students drew on the experiences of their parents and siblings to make this point.

Vignette: Teachers are like sharks!

Student perception that interaction with teachers involved risks was highlighted as Kate was explaining that she had asked some of the students to, "See me." The class told her they "hated" this sort of teacher comment because they assumed they had "done something wrong" and would "be in trouble" or be "yelled at." One student burst out, "Teachers are like sharks." The class concurred. Kate was obviously stunned by this assertion. She asked the students if they could recall that she or any other teacher within the past two years had shouted at them. Only two said they could but they all assured her, "You never know what will happen."

Despite the variability in student experience of teacher responses most students desired more opportunities for informal interaction with their teachers, particularly in small group and one-to-one settings. They considered they received more useful feedback on these occasions because they were more explicit about their queries and concerns.

The LISP students also indicated that the teacher action of taking time to explain and re-explain ideas functioned as feedback because this action communicated to them that the idea was important, *and* that the teacher expected that the student would be able to understand it. The following vignette is taken from a discussion of a lesson that students considered particularly effective because the teacher had not 'rushed' through the lesson content, rather she had taken the time to ensure the class understood the idea of density:

Vignette: Not rushing

S74 Today, I think she took more time with it [explaining the concept of density].
S75 She is not really a rushed teacher. Like before she finishes it she makes sure that everyone understands.
S76 Everyone has the right idea.
Res. So is taking time important?
S's Yes.

These examples illustrate how, under scrutiny through a sociocultural lens, a range of direct and indirect teacher actions come to count as feedback because they serve as information that focuses student learning attention and action and shape student understanding of what is valued and their own competence or sense of identity as a science learner.

A lack of confidentiality of information disclosed to teachers during informal interactions is another aspect of the ethical principle. Some students reported that they could not be sure who would be the eventual audience for their comments and actions. In support of this claim they described how teachers sometimes responded to a private question by attracting the attention of and replying to the class as a whole (Cowie 2000). Students realized this teacher action was an attempt to provide feedback to other students who might have the same query, but the students involved experienced the action as a breach of trust. Some of the older LISP students also reported that teachers shared their help-seeking actions and comments with their parents and other teachers. The issue for them was that their tentative ideas were taken out of context and took on a semi-summative status, one the students had not anticipated, given their ideas were in the process of formation. Some students considered information used in this way could have a long term (negative) impact on their reputation (identity) suggesting the need for teachers to be more cautious in how they discuss student learning with others:

> The thing is teachers do talk amongst themselves in the staff room. And it gets around that [a student] didn't know what she was doing in science and she is not good at this. So the teachers will go back with that attitude. And it sticks with that person.

On the other hand, when they could choose the time and place most students relished sharing their learning with their teachers and families. They actively sought out teacher feedback on completed work and encouraged their families to view their work when they visited the classroom and during student-led conferences at report evenings. Harm in this case was to do with the interim nature of the information reported and not the reporting per se.

Overall, student commentary highlighted the crucial importance of mutual trust and respect. In the words of one student, 'I think it all comes down to respect. How much you give them [teachers] and how much they give you.' Only when students trusted teacher and peers to be well intentioned were they prepared to take the risk of subjecting their ideas to public scrutiny and debate. Others have also found that respect is a key factor in teachers earning students' confidence and creating an environment that supports curiosity and engagement with intellectual challenge (Tobin 2006). These students concerns suggest the LISP teachers were wise to ensure that their interpretations and actions were both care-referenced in the sense of being aimed at nurturing their relationships with their students and students' affiliation science and science-referenced and aimed at moving student science understandings forward (Cowie and Bell 1999). The teachers' use of care-referenced actions is congruent with an ethic of care (Gilligan 1982), which may provide a way of conceptualizing the ethical aspects of classroom assessment (Carr and Cowie 2002). An ethic of care highlights the relational nature of learning. It supports the development of the classroom as a community of learners whilst maintaining a focus on developing student disciplinary knowledge.

Access and Opportunity for All – The Equity Principle

Equity is associated with a concern for fairness and matters of social justice. As a principle for classroom assessment, equity is entangled with the appropriateness of opportunities students have to demonstrate what they know, and can do, and to get useful feedback on this (Moss et al. 2008). Within a sociocultural view, it is taken for granted that different task modes, formats and audiences will provide different evidence of, and insights into, what a particular child knows and is inclined to do. Within this view there is value in students having multiple opportunities to express their ideas because different tasks and modes used in combination can compensate for, and complement, each other. Scientists use a range of language, mathematical, graphical, diagrammatic, pictorial and other modes to develop and represent knowledge (Lemke 2000) and so it is important that students have opportunities to develop science identities that include proficiency with a range of representational means (Carlone et al. 2008). Adding further weight to the need for this, the work of science education researchers working with an equity agenda, even though they have not often focused directly on assessment, has illustrated the value of teaching and assessment tasks that include drawing, drama, the production of books and video and other modes (see for example Fusco and Barton 2001). Given all this, it is not surprising that the LISP students challenged teacher reliance on a single task/mode to make judgments about what they knew or could do. These students readily listed the limitations of tests, teacher observation, and bookwork. The InSiTE and CRP&A studies have provided ample evidence of the value of students having multiple, multimodal and multi-focal opportunities to show what they know and can do as the following example illustrates.

Vignette

A class of five year olds that were part of the CRP&A study learnt about *tuatara* [a type of reptile distantly related to snakes and lizards] through a field trip visit to live tuatara, reading books and viewing photographs and video on the Internet. They represented what they knew through a series of drawings, dictated statements and questions, acting out how tuatara move, and making a clay model of a tuatara and a box-model of tuatara habitat. Their clay models, along with their comments during the production of these models indicated they had an appreciation of the proportions of tuatara, the scaly texture of their skin, the structure of the claws on their feet and their spiny back (tuatara is a Māori word that means spiny back) well beyond what was evident in their drawings or conversation alone.

We have found, as others have (see for example Elmesky and Seiler 2007), that it is of value for students to have an authentic social purpose for demonstrating what they know and can do. All of the classes involved in the QTR&D study presented the outcomes of their learning to the community groups they had engaged with and or other students in the school. Within the New Zealand setting this action is consistent with the principles and the cultural responsibilities of tuakana teina where the more expert and knowledgeable person (tuakana) helps and shares his or her knowledge with the more novice and less knowledgeable person (teina).

The principle of equity in classroom formative assessment is associated with how assessment, even informal assessment, constructs what counts, and does not count, as valuable knowledge and achievement and who gets to decide this (Gipps and Murphy 1994). Equitable assessment processes need to accommodate, recognize, value, and respond to, the full breadth and diversity in what students know, understand and can do. When learning involves identity work teacher science assessment needs to do more than converge on the taught curriculum to identify student alternative science conceptions. It also needs to be divergent so that teachers find out what a student actually knows (Torrance and Pryor 1998). For this to happen, teachers need to encourage and support students to share the funds of knowledge (Gonzalez et al. 2005) they have developed within their families and communities and to incorporate these into the curriculum as resources for student learning. During the InSiTE lessons, student contributions of their out-of-school experiences as resources in class discussion included descriptions of baking, working on car engines with their fathers, and seeing snow on power lines, to list but a few. In this way, students were positioned as authorative in matters over which they had personal experience. At the same time these contributions enriched the learning of their peers (Cowie et al. 2013).

A further aspect of the equity principle, one that is imperative in the New Zealand context because of its bicultural nature as set out in the Treaty of Waitangi, is the need for teacher attention to the broader cultural funds of knowledge of their students. Mason Durie (2001) summed up this obligation as follows: the New Zealand education system needs to enable Māori students to live and succeed as Māori *and* as citizens of the world; Māori are the tāngata whenua (indigenous people) of Aotearoa (New Zealand). Put another way, Māori students should not have to leave who they are at the classroom door in order to succeed in school science – Māori students need to feel respected and proud of who and what they are as Māori. The same is true of all students. The following vignette illustrates how one of the QTR&D teachers brought Māori knowledge and ways of knowing into respectful conversation with Western science to provide a learning environment in which everyone was a learner. This aspect of the equity principle acknowledges that students live in multiple cultural communities, each with their knowledge, practices and values that can serve as a resource in the classroom.

Vignette:

Tina's year 6 students chose to study landforms and decided to explore Mäori stories that explain the existence of important landforms in the local area. Tina acknowledged to her students that she did not know the names or stories of any of the local maunga (mountains) and so, 'I'm not going to be much help to you'. The students were more than happy to find out for her, with one telling her, 'We can find out and tell you.' And another student told her, 'My koro (grand-dad) will know some of the stories and we can ask Whaea" (Aunty). Yet another said, "There is a maunga out at Te Puke – I don't know the book story but I know there is a waiata (song) for it and I can ask my Mum." As students gathered the legends that explained the Māori worldview about local maunga, students posed questions about the Western worldview:

Student: Whaea [Auntie/teacher], how did Whakaari really get out into the ocean – because mountains can't really jump?

> Tina: If you think that there is another story – how could you find out what that story is?
> Later, when asked to identify what they knew about these worldviews of science one group knew that Whakaari was White Island and it was a volcano. They had accessed a book on volcanoes and posed questions for each other about the validity of the island being a "real" volcano.

Throughout this unit the students appeared to experience no difficulty in respecting the stories from their different iwi (tribe) and communities, which often presented different histories and meanings for the same landform, and the science explanations they accessed from the teacher and the Internet. Indeed, the student comment that mountain can't really jump indicates that this student appreciated that there are different explanations that are appropriate for different contexts and purposes. The students sought out a range of knowledge sources to answer their questions, from Kaumātua (elders) to the Internet, and were keen to share their learning with others. As noted earlier, this was entirely culturally appropriate and Tina arranged for them to talk with some junior classes.

Inviting students' funds of knowledge into the curriculum as a valued resource of knowledge created a situation in which the students experienced a positive interaction between their school science and home/community identities, to the apparent enrichment of both. The teacher's respect for, and affirmation of, the students in this way was important feedback to them that contributed to their identities as learners and knowers. The teacher positioning of herself as less-knowing in this unit was typical of the ten teachers in the QTR&D project. All ten teachers described finding this loss of power and control disconcerting and uncomfortable. However, they all found their students responded in a responsible and positive manner to this situation and, as a consequence, the teachers were keen to continue working in this way.

Conceptual Agency in a System of Accountabilities – The Engagement Principle

The last principle of formative assessment is that it needs to support student engagement. Student engagement with science is a concern worldwide, particularly for minority and indigenous students, as was noted within the equity principle. This principle then overlaps with, and builds on, the equity principle, to focus more directly on the development of student science identities. For the purposes of this chapter, engagement is defined as the exercise of conceptual agency within a system of accountabilities. In this definition we draw on James Greeno's (2006) description of conceptual agency as meaning students are positioned with authority and accountability and treat the concepts, methods, and information of a domain as resources that can be adapted, evaluated, questioned, and modified.

The engagement principle provides a sociocultural interpretation of the goal at the heart of formative assessment – the promotion of student self-monitoring of (science) learning during the process of the learning (Sadler 1998, p. 1). It locates student self-monitoring in the patterns of participation that involve the interplay of

student authority and accountability around science knowledge generation, presentation and legitimization. This orientation construes action, power, authority and accountability as situated (Wertsch 1998) and hence dynamic and open to change and challenge. Seen this way, a student's pattern of engagement and agency is an important aspect of his or her identity. Rather than student agency being viewed as a fixed attribute it is understood as linked to, but not fully prescribed by, the opportunities a student has to act (Gresalfi et al. 2009). Hence, the way a teacher orchestrates the learning environment to position students with different forms of authority and accountability is important. Teacher actions can open up, and can close down, spaces of possibility for agency and formative student self-assessment through the way they distribute knowledge sources and share power and responsibility (Cowie et al. 2013). For instance, students can be expected to defer to the teacher in their positional roles and/or they can be held accountable for explaining and justifying their ideas and actions to peers and the teacher. In science, in particular, they can be held accountable to science as a material practice that aims to explain the behavior of material phenomena (Ford 2008). Next, some illustrative practices are provided to show how this principle might be instantiated within classroom interactions.

As might be expected, the engagement principle encompasses commonly recommended teacher formative assessment practices including the need for teachers to specify learning goals and be open about their criteria for quality and success in learning. When students do not understand their teacher's goals for a task they develop their own meanings for it and can construe it as time-filling busy work (Cowie 2000). Similarly, teacher feedback in the form of grades and comments such as 'well done' and 'keep it up' does not serve a formative function beyond 'making some students real happy and they'll try to do it again' (see also Dweck 1986). Indeed, one of the LISP students, a Year 8 (age 12) girl, went as far as to assert that, "Parliament should make a law that teachers have to say *because*. They always make us explain why." She was frustrated that grades offered no information to help her understand why her work was of high quality or low quality and how she could improve. Quality feedback, in the form of suggestions, was preferred when students were pursuing learning goals because suggestions could be incorporated into students' own ideas and "keep us thinking." In addition, suggestions were said to communicate respect that, as noted earlier, many of the students in the LISP study considered fundamental to effective interaction. This said, students do not always pursue learning goals nor appreciate feedback that opens up possibilities for dialogue and thinking. Sometimes they are simply interested in completing a task; at other times they appear to be captivated by the manipulation of novel equipment; and at yet other times they obviously have other priorities in their lives.

Teachers in the three studies leveraged the nature of science as a material practice to distribute accountability in a way that allowed them to defer, but not necessarily completely withhold, the exercise of their own authority as representative of the discipline of science. What follows is an example of this process in action. In this episode the teacher encouraged the student to test out his own ideas knowing he would not be completely successful. Her action took into account her experience

that the student was unlikely to be persuaded by unilateral statements. She chose to allow him the time and space to find this out.

Vignette: Separating salt and sand

During the second lesson of chemistry unit, the teacher asked the students to separate a mixture of salt and sand. Most students did this by dissolving, filtering and then evaporating the mixture. One student requested tweezers. The teacher discussed the viability of this strategy with him and then provided him with tweezers. He sorted some of the crystals by hand and then asked for a magnet [some of the local beaches as black sand beaches with high levels of iron]. Twenty minutes into the lesson the student concluded his strategy would not work. He dissolved, filtered and evaporated the murky white mixture he had produced. This student used these insights in later separating challenges.

In considering this episode it is important to realize that for the participating student and his peers the episode had meaning beyond the moment. Firstly, it was made possible because the student knew that the teacher was prepared to support students to explore their own ideas. Secondly, it had meaning into the future because it illustrated and reinforced the interplay between student conceptual agency, teacher authority and material accountability. The students interviewed after the lesson, (eight in two groups of four) were not surprised by the teacher's actions they reported she did not "put down" their ideas:

Student 1: She never, like, if you give an answer, she never puts it down and says, "You're a bit off track there."

Student 2: What she has done to me before is say "I understand that bit but this bit here, please can you explain it for me."

Students: Yes, me too.

The power of this episode derived from it being part of a long-term pattern of interaction that supported student conceptual agency in conjunction with the need for students to consider the extent to which their ideas could explain any experimental results, or what could be termed accountability to the material dimension of experience.

Teachers focusing students on sets of examples and evidence and orchestrating a discussion to consensus about common characteristics or patterns was another commonly used teacher strategy that successfully enacted student agency within a system of distributed accountability. In this situation, students were held accountable to their peers to provide a coherent justified explanation that encompassed all the evidence available to them, leaving the teacher free to affirm rather than simply convey the disciplinary view.

Vignette:

An example of this practice occurred during the first lesson in a science unit on force. Brenda introduced the notion of a force as something that caused motion by modeling moving a pencil, a table and a ruler using exaggerated movements. As she did these actions she questioned the students about what she was doing to cause movement. One student recorded student suggestions on the whiteboard. These suggestions included pushing, blowing, kicking, hitting and so on. At the end of this teaching sequence there were five lists of movement actions recorded side by side on the whiteboard. A student then called out, "Miss G, they all have 'push' in them." Brenda picked up on this comment and asked the students to consider to what extent the written movement actions involved pushing. Discussion ensued

and the class concluded that most did. Another student pointed out the movements also involved a pull, "the opposite of a push." Brenda reinforced these two observations and then told the class that the scientific definition of a force was that it is a push or a pull.

However, this process requires careful selection of examples. In one case, the teacher provided set of fossils but did not include a specimen from something that was still alive. Subsequently, it proved very difficult to convince the students that current living things could be fossilized (Cowie et al. 2012).

As James Greeno (2006) pointed out, student independence and easy access to resources and practices to test out their ideas and inform their thinking can support student conceptual agency (see also Engle and Conant 2002). This practice does however rely on students being able to recognize the potential of, and be willing and able to use available resources and practices. What follows is one of the most striking examples we saw of the role resources can play in informing student thinking when a student is motivated to achieve a goal and actively interrogates available resources to do this.

Vignette:

Roger struggled to express himself in Chinese and in English but when tasked with making a kite he observed closely how the teacher modeled this activity, simultaneously making a kite and drawing up an action plan for the process. His first kite was a success. When his second kite did not fly very well he compared it with a commercial kite and his first kite and made adjustment to the kite tails to bring them into line with those on his first kite.

While Roger's actions characterized him as agentic the teacher's willingness to allow him to pursue his ideas contributed to the way he was able to explore his interest. The next day he brought a book to school that included a plan of a box kite. The teacher helped him share this with the class and supported him in his attempt to use the plan to make a box kite. Three months later Roger used an action plan to develop a fridge magnet as part of a social studies unit. While we did not observe the translation of learning from one context to another very often, actions such as this are significant as evidence of the ability to recognize and use knowledge in a new context. This example not only highlights the temporal aspects of learning, it also raises a challenge to us as researchers and teachers. This challenge relates to the imperative for teaching and assessment to contribute to student use of their learning across contexts, place and time. Assessment needs to be 'sustainable' in that it contributes in some way to student learning beyond the immediate task and prepares students to meet their own learning needs (Boud 2000). Put another way, assessment needs to help students learn how to learn science.

The example of Roger shows him accessing and using the material resources in the classroom but students in all of the classes we have worked with have compared their work with that of peers and sought out help from them. Indeed, many students consider peers provide more useful feedback than teachers because their feedback is timely, they better understand where the student is coming from, and they use more accessible language. Students discussing their ideas with peers can be an effective teacher strategy that supports both accountability and the exercise of authority. The diffusion of ideas that happens when this is possible is illustrated by the way the notion of a spring spread around one of the InSiTE classrooms.

Vignette: Diffusion of the idea of a spring

A year 4 student developed a spring to increase the performance of the tongs he was designing. Spring making and use quickly diffused around the class through a combination of word of mouth and student visits to the spring designer's table. Interestingly however, no group retained a spring in their final product; the springs they were able to make were not robust enough for the task.

Teacher use of student work also serves this dual purpose. When teachers position student work as a reference point of accountability they simultaneously position the author as authorative. In the following example, adapted from Paula Wine and Judy Moreland (2007), the student work was student experimental results and the teacher's public posting of the results served to distribute the authority within the classroom and, at the same time, position students with warranted conceptual agency.

Vignette: Student work as a source of accountability

Paula's students were charged with developing a fermented drink. To help with this they conducted a series of investigations into the conditions required for yeast to live. Paula posted the student result tables on the classroom wall. The students took particular care with the conduct of the experiments and presentation of results knowing these would inform their own and their peers' decisions. Students made active use of the results in deciding on the recipe for their fermented drink. The results sheets provided the students with the data they needed to do this, with the added benefit that students were able to discuss the meaning of the results with the investigators.

Taken together, the practices used here to illustrate that the principle of engagement highlight some of the ways teachers can think about shifting traditional teacher-student power relations by establishing patterns of participation that support student authority and accountability within a learning/self-assessment process. Student conceptual agency is inextricably tied into teacher-student power relationships in the classroom, including who can act with authority and how their authority is backed and to what/who it is held accountable – by evidence, evidential explanatory power, by reference to disciplinary norms and concepts, by positional power, or by social agreement.

Expanding Visions for Formative Assessment

In this chapter I have advocated for a quality of assessment that contributes to student identity through the exercise of conceptual agency expressed via authorative positioning, within a system of accountabilities that includes the material world, consensus with peers, coherent justified explanations, and teachers as representative of the discipline of science. I have proposed and provided some examples of three principles for the conduct of formative assessment in primary science classrooms when learning is viewed as a transformation of identity, and priority is given to assessment informing learning. In this case, quality formative assessment comprises all those practices that open up opportunities for interaction and student expectations of, and practices for, developing expertise as knowers, learners and users of science, now and into the future. In this conceptualization, formative assessment practices such as the provision of feedback, for example, become more than a

discrete strategy to do with the provision of information about a science idea or a task. Rather, feedback comprises a constant stream of information that contributes to students' identification with and identity as science learners and knowers. In this case, the ethical principle speaks to the need for respectful relationships between teachers and students whereby teachers are sensitive to the ways classroom assessment can construct and undermine student identities as knowers, learners, and users of science in ways that also impact on their relationships with friends and peers. In practice, assessment has consequences for student social-relational, affective, intellectual, and task completion goals simultaneously. When conflict arises between completing tasks, social-relationships and effective learning, students often prioritize their social relationships. If they fear that their feelings or reputation may be harmed, they may limit their participation. Students need to feel safe within a relationship of trust and respect before risking exposure to formative feedback (Cowie 2005). The equity principle focuses on the need for classroom assessment to support the learning of each and every student in a class, individually and as a collective. It prompts teachers to acknowledge, respect and call on the diverse ways in which students can represent what they know and can do, as well as the rich funds of knowledge they have for making meaning. The engagement principle zooms in to consider the nature of the science identity that is desirable for students. I have defined engagement in the sense of conceptual agency where this involves interplay between authorative and accountable positioning. Students can be positioned as authorative in the generation and sharing of new ideas and through the sharing of the funds of knowledge they have developed through their engagement in family and community life. They can be held accountable for their ideas and actions to peers, the teacher as a representative of the discipline or as the person with most positional power, and to the material aspects of the practice of science. Each of these aspects needs to be held in dynamic tension as each is important.

Classroom assessment, including informal formative assessment interactions, constructs and relies on differentials of power. Typically, these position teachers as being in control of what counts as knowledge; who has access to really useful knowledge; who has ability; who controls the teaching space; who is valued as an individual and a learner; and whose voice is given credence (Munns and Woodward 2006). Before this situation can change, teachers need to learn to share responsibility with students and students need opportunities to learn how to exercise authority within a system of accountabilities that is not teacher dominated. This relies on teachers having a non-deficit view of students in more than one way: that the sharing of power will not undermine but contribute to mutual respect between teachers and students; that students will respond responsibly to an increase in authority; and that students have funds of knowledge to share. However, sociocultural views highlight that these changes can be enacted through subtle changes such as taking time to respond to student ideas and resourcing the environment with materials that can support student authority and hold them accountable.

Sociocultural views of learning acknowledge the influence of the immediate classroom as a context for teaching, learning and assessment. They also recognize the influence of the wider context. Those thinking about the merit of the principles

and associated practices outlined in this chapter will inevitably need to consider how wider assessment, accountability and curriculum policies and practice requirements might act to enable and constrain teacher priorities and actions in their context, and the implications of this for student science learning.

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Chapter 7
"And? Did We Do Nice Things?" Children Documenting Their Emerging Inquiries in Early Science Learning

Charles Max, Christina Siry, and Martin Kracheel

Doing Science as an Interactional Achievement

In this chapter, we discuss a study investigating ways in which science emerges from young children's interactions. It examines the context specific ways in which these children make sense of science phenomena. A core focus of our work is to develop and explore possibilities for including children's perspectives and insights about science phenomena in our research, both in the inquiry and learning processes.

Our research situates the doing of science as an interactional achievement (Pekarek-Doehler and Ziegler 2007) and a cultural enactment (Tobin 2005). We seek to explore how a socially shared topic (such as scientific phenomena) is explicitly established through the interactionally accomplished convergence of talk, embodied action and artefacts-in-use. Particular attention is paid to the spontaneous ways children describe, explain, interconnect and reason about phenomena and, more generally, how they talk their joint experiences into being. Regarding the context-sensitive organization of their talk around collaborative inquiry processes, we consider the multi-modal quality of the young learners' semiotic resources they draw upon as they "do" science within multilingual interactions. Hence, the research provides evidence of the children's apparent and emergent discourse practices, features and formats from diverse learning contexts, within school and beyond.

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The study centers on young children's explorations of the natural, chemical, and physical properties of water in open workstations. It strives to evidence how 4- to 8-year-old children express, display and share their increasing scientific understandings within open collaborative inquiries. The constructionist research approach stimulates and supports a range of interactive situations. By working in cooperation with the classroom teachers, we create opportunities for dialogue and exchange with and between young children before, during and after the investigative science activities. In the sections that follow, we discuss the issues that arose when children collaborate as co-researchers in a science learning activity. First, we analyze to what extent young children manage to document 'doing science' with small portable cameras and how this can open a dialogue between children and adults. Second, we discuss how our collaborative research approach might reshape the roles of children and adults.

Engaging in Cooperative Inquiry with Children Around Science Learning

The study was conducted in Luxembourg from 2009 to 2011, where fundamental schools serve children from ages 3 to 12 in four 'learning cycles'. In this system children stay generally with the same teacher team for two-year cycles. Our work concerns the first two cycles in the fundamental program. Cycle 1 constitutes the early education program for children aged 4 to 6 years. Cycle 2 entails the two first years of primary school, usually labeled also first and second grade. According to the official curriculum, early childhood education is conceived as a multidimensional social experience stimulating rich interactions with other individuals. Education at the cycle 1 level fosters a holistic development of competencies, including all the senses and the body, emotions, intelligence, language(s), movement, appreciation of culture, music and art work, social development, and moral awareness. Pedagogical practices, as presented in the official curriculum, are expected to leave space for creative activities and play as this is seen as an important way of learning and expression during the early years. Cycle 2 entails a discipline-specific curriculum with a set of predefined competencies the child is expected to acquire during a two-year period. They refer to language learning (German and later on also French), mathematics, science, kinesthetics, aesthetics (music, culture and art), social development, and moral awareness. At cycle 2 level, curriculum topics/themes are no longer taught from a multidisciplinary perspective and through whole week projects (as they are in cycle 1) but through 1-h lessons that are given by the class teacher. A team of teachers coordinates the classes within a given cycle.

Our approach intends to support teachers in conducting science investigations that stimulate open-ended interactions between children. The teachers we collaborated with were open to the concept of science inquiry and agreed to organize science activities with children around the topic of water. We use the term "cooperative inquiry" in this chapter. With this notion we are referring *both* to the act of engaging

in scientific inquiry around the topic of water, as well as the fact that the children are participating in the research process, which in and of itself is also an inquiry. As cooperative inquiry is not a common school practice in this context, we had to first conceive how such an approach could engage children, researchers, and teachers together in science workshops *as well as* in the documentation and analysis of data around their science learning. An activity-theoretical approach is one way to describe the hybrid project community we created. We draw on Engeström’s third generation of cultural historical activity theory (2001) to analyze how the two different ‘activity systems’ of the local teacher team and the academic research group interact and expand their objects through dialogue and developmental work.

> This expansion approaches both objects and outcomes in a partial overlap. In this cross boundary object ‘exchange’ a new object 3 appears. This ‘third object’ gives rise to a ‘seed of transformation.’ In other words, the newly-appeared ‘third object’ gives rise to a driving force for the transformation of the original activity system by means of feedback to the respective activity systems. (Yamazumi 2005, p. 78)

Our ‘third object’ focuses on the emergence of the active roles that the children played in the research process. The systemic view (see Fig. 7.1) allows for modeling the interactional dynamics within and across the research context at a structural level and as looking at it from above. The triangles display the ‘cycle 2 science classroom’ as a zone in between the activity systems of school and university with their related object, tools and expected outcomes. Furthermore, Fig. 7.1 represents the construction and instantiation of the new object of the water inquiry workshops where the children *turned out to be central* for structuring, understanding and co-documenting the overall process.

Cooperative inquiry is seen herein as a journey across contextual boundaries, where practitioners from both activity systems (i.e., university and school) have to review their well-established practices and assumptions when entering new grounds. We direct our attention towards the emerging roles of co-inquirers that the children played in the ‘in-between space’, where dialogue, meaning making and multi-perspective negotiations among all participants took place.

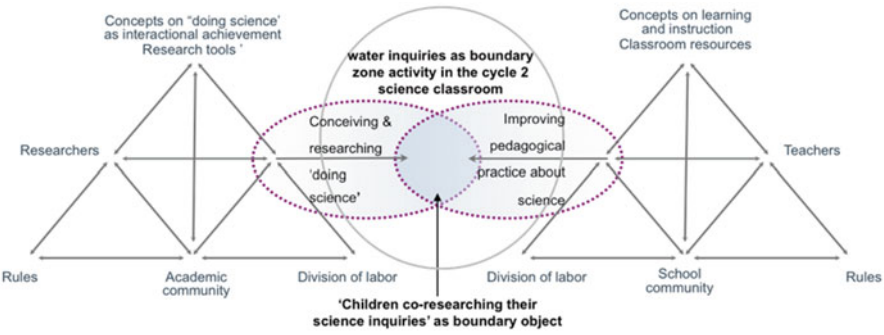

Fig. 7.1 Systemic view of the cooperative inquiry project (Following Tuomi-Gröhn 2005, p. 34)

In the 'cycle 2 science classroom', the interactions between the two systems generate a shared object, i.e., facilitating and documenting children's learning of science in an open inquiry culture and with the children co-researching their learning process. That object gives a durable direction and purpose to the local (science) activity context under scrutiny. Researchers and teachers cooperate on designing science tasks that emphasize child-directed investigations and explorations on water-related phenomena and on documenting the emerging interactions during and after the investigative phases. Children do the inquiry in these phases through the mutual contextualization of a range of semiotic resources and the context-sensitive use of cultural artefacts, which are brought to or offered in the institutional context. In the next section, we discuss the role of children in this process, and ways in which researchers, teachers and students began to partner in the inquiry process, as they are engaged in the topic.

The Role of the Children in the Research Process

There is a growing interest in conducting research *with* children instead of research *about* or *on* children (see Christensen 2004; Clark 2010). Participatory approaches to conducting research (Park 2006) do not simply consider children as the pure object of research, but as knowledgeable and competent experts of their life experiences. Children get involved actively in the research process and their persepectives become central to the research. Studies within the sociology of childhood domain (see Christensen and James 2008) present children as co-researchers within a multi-perspective and constructionist research paradigm. Children bring unique insights about processes and events of their daily lives to the data collection that are valued as being complementary to the researchers' perspectives. Our research on science learning adds a knowledge creation view (Paavola et al. 2004) to this approach, which emphasises how the children's acting shapes and is shaped by the learning context in the legacy of sociocultural and cultural historical perspectives on learning (Vygotsky 1978). Children take an active role in knowledge building and meaning making within the science learning context (Rogoff 2003; Roth and Tobin 2007). As co-inquirers, they bring rich and original information about their ongoing understandings and learning to the research context.

Our research approach is achieving a multi-dimensional and context-sensitive view of children's practices, which are distributed among people, time, space, physical environment, semiotic and tool mediators. In this sense, the unit of analysis goes beyond 'individual heads' as we strive to "account for social situatedness (role/identity/subjectivity issues), cognitive activity, discursive and local context, and attempts to address how these phenomena mutually influence one another" (Thorne 2000, p. 237f.). Units of analysis are always partial, incomplete and open (Matusov 2007) and we argue that they should be partly defined by the research participants, which involves dialogue with the people participating in the study (Rogoff 1995).

The Inquiry Culture of the Cycle 2 Science Classroom

Our data corpus consists of video data that illustrate a wide range of collaborative science investigations initiated by 6- to 8-year-old students. In this paper we narrow our focus to one cycle 2 class of first grade students. In that particular class, the classroom context was structured so that three to four children worked with everyday equipment to investigate water properties in four science workstations. The teacher-defined working groups remained consistent across the project time, as they worked together for science investigations and reflection sessions. The science tasks were designed by the teacher to generate a maximum of interaction opportunities during and after the manipulative phases. During experimentation phases, the children’s inquiry often took a playful, explorative, improvisatory, imaginative, and unconventional approach. After the exploration phase, children stayed in the same small groups to document their ideas, reflections, interpretations, and thoughts for further inquiry in areas next to the classroom (e.g., corridor, medical room…). In these reflection phases, children used small video cameras to document their ideas and discussions around the science investigations. Our research framework strives to combine the system view (see activity-theoretical modeling in Fig. 7.1) and the subjects’ views. With respect to this principle of multivoicedness as stressed within cultural-historical activity research, the views of the classroom participants (teacher and children) “through whose eyes and interpretations the activity is constructed” (Engeström and Miettinen 1999, p. 10) are important for our analysis.

Classrooms are “more than open spaces with furniture – they are cultural sites where children and adults enact a series of cultural practices, including ‘doing school,’ ‘doing lesson,’ ‘doing classroom reading and writing,’ and ‘doing learning.’” (Bloome et al. 2005, p. 44). As such, there are various discourses present and interacting in and around classrooms. These discourses structure, and are structured by, the ways that the children and adults co-configurate the science learning events into being.

In the sections that follow, we present a series of connected vignettes in order to situate the children’s documentation of their own inquiries within the framework presented above. We are interested in the ways in which these children, who have shared experiences around the investigation of water, express, share, combine and reflect their scientific understandings as co-inquirers. Furthermore, we gather evidence about the dialectical ways in which the children’s actions shape the context of the science classroom and how, in turn, the context of the classroom shapes children’s practice.

Extract A1

The first exchange shows an example of the ways in which three children (Pit, Ann, Jil) are documenting their experiences using a video camera. We present a longer excerpt of their conversation with the related gestures and actions. Then we

analyze it more closely in the section that follows. Spoken talk is transcribed with GAT (Selting et al. 1998), a transcription system that has been developed by a group of German interactional linguists in line with CA transcription conventions (Jefferson 1985). From the three levels of delicacy that GAT allows, we use the basic transcript version for the present purpose. The second line in the transcripts contains an approximate translation of what is produced in the original transcript. Some transcription symbols are reproduced in this translation line for facilitating reading.

The three children are in the hallway outside their classroom. Before the following exchange occurs, the first author (Charles) who is one of the researchers (referred to in the transcript as Res) hands the camera to Ann, and explains to the children "*you can talk about what you have found out, and when you are finished, you push this red button.*" Jil responds, "*okay,*" and the following interaction comes about.

```
A01   Pit   ((raises his hand)) (--)
A02         puer (.) puer saachen die sin net ënnergaangen
            a few (.) a few things they did not go under
A03         a puer saachen sin ënnergaangen
            a few things did go under
A04   Jil   ((turns to Pit and cuts talk by raising arm in front of his face.
A05         e(t)sch ((She is mimicking the board called the "slate" in filming))
            i(t)sch ((it is like a combination of I and the sound tsch))
A06         elo emmhh (.) emmm (-)
            now, ummhh (.) ummm (-)
A07         puer saache si ganz ënner puer sache si ganz uewen
            a few things went all the way under and a few stayed all the way on the top
            (1.0)
A08         tscht ((raises hand and moves it quickly down))
A09         ((looks to Pit))
            (1.0)
A10   Pit   a puer sachen (.) em sin eeh (--)
            a few things (.) um, did eeh (--)
A11   Ann   <<whispering> zum beispill holz>
                        for example wood
            (2.0)
A12   Pit   ((makes facial expression))
A13   Jil   ((dances away and comes back))
A14   Ann   <<whisper> zum beispill holz as ënnergaangen oder uewebliwwen>
                    for example wood went under or floated
A15   Jil   ((dances away and comes back))
A16   Pit   holz as ënenrgaangen: [ode::r
            wood went under:      [o::r
A17   Ann                         [<<whisper>()>
            (1.0)
A18   Jil   ((dances around and approaches Pit from behind putting
             her hands above his head to simulate ears))
A19   Pit   oder de magnéi:t
            or the magnet
A20   Ann   <<whisper>jil, hal op>
                    jil, stop it
A21   Jil   ((giggling))
A22   Pit   de  ma[gnéi:t
            the ma[gnet
A23   Ann         [a wat as nach ënnergaangen
                  [and what else went under
```

To look closer at the processes occurring during this exchange, we describe relevant fragments in the transcript in more detail. At the beginning, Pit quickly raises his hands and selects himself as the first speaker (line 01). He initiates this exchange by enthusiastically explaining that some of the materials they had investigated sank, and some had floated (lines 02 and 03). As soon as Pit has finished his statement, Jil gazes at him, raises her hand in front of his face and says *"i(t) sch"* (line 05). This combination of a verbal utterance and an iconic gesture resembles an action done with a slate in filming and has primarily two functions. She claims the floor and tells Pit to stop speaking. Furthermore it shows that Jil is aware that the cultural practice of recording a clip or making a movie is happening right now. Jil then starts her utterance by *"now"* and adds her clarification to the concept of *"going under"* or *"staying on top"* as she elaborates that "*a few things went all the way under and a few things stayed all the way on top"* (line 07). She closes this sequence herself by producing after a pause again a similar sound "*tscht*" (line 08) together with the same kind of gesture, this time directed to the ground. This closure is co-constructed by Pit with the establishment of mutual gaze (line 09).

Within the continuation of the exchange, Ann, the girl holding the camera, takes an interesting role, as she quite actively structures the talk. As Pit hesitantly repeats *"a few things (.) em are eeh"* (line 10) Ann offers a continuation of the phrase by whispering *"for example wood"* (line 11). When Pit then signals with a facial expression that he did not understand, she elaborates on her suggestion and whispers *"for example wood went under or floated"* (line 13). We can observe that the child operating the camera takes an active role in structuring the talk. This phenomenon is evident in other moments as well. Children seem to enact this role when the camera is passed from one actor to another (compare Extract C2).

Ann structures the talk in a way a teacher or an interviewer would do, offering two possibilities as she suggests answers. First, she whispers *"for example wood"* (line 11) and then whispers another clearer suggestion of *"for example wood went under"* (line 14). When Pit takes up the first part of her suggestion in line 16 *"wood went under"* she quickly reacts to it with another whisper, which may push Pit to add *"or the magnet."* At the end of this extract, she starts to ask quite precise questions to Jil and Pit (see Extract A2). This underlines the importance of shared experiences for talking about the group's previous explorations. Ann is well positioned to make these suggestions because she participated in the science inquiry activities that they are reflecting upon. She is managing the camera, which seems to put her in the role of a reporter (lines 11 and 14) or questioner (line 23). In fact, her suggestions are grounded in shared experiences and intimate knowing about what grew from these investigative experiences.

Additionally, there is a meta awareness of the ongoing recordings. Pit and Jil are speaking right into the camera, but look at each other or make gestures to contribute to the conversation. Ann is whispering to Pit and Jil as a kind of stimulation or help for the ongoing documentation process. As such, the possibility to create recordings shapes the ways in which children engage in the particular (boundary) activity. Their possibilities for individual and joint acting are mediated by the means that the

sociocultural context provides, or, as Wertsch (2000) puts it, "are always enabled, or 'afforded', as well as 'constrained', by cultural tools" (p. 502). Jil is quite animated in this exchange, as she moves her body through the physical space, dances around, giggles, and makes silly gestures behind Pit's head. Nonetheless, she is actively contributing to the discussion about what happened during the sinking / floating investigations, as we will see in the following exchange from the same episode. This emphasizes the "paradigmatic importance of intercorporeality" (Streeck 2009, p. 201) when analyzing the quality of interaction in collaborative activities. Through their kinesic and proxemic behavior, interlocutors display various types of stances towards the activity as they "can either choose to willingly participate in ways that display their engagement or refuse to cooperate in the course of action" (Tulbert and Goodwin 2011, p. 79). The next exchange picks up immediately from the previous Extract A1.

Extract A2

```
A23   Ann          [a wat as nach ënnergaangen
                   [and what else went under
A24   Jil    <<loud> eemm:::> ((steps next to camera and in front of pit))
             (1.0)
A25          e den hä:rz ((drawing a heart with her hands))
             e the heart
A26          (.) den härz ass [uewen= ((lifts up arms in the air))
             (.) the heart is [on the top
A27   Ann                     [<<loud> =eng klamer eng klamer=>
                                a clothespin a clothespin
A28   Jil    =eng klamer den härz d'klam war futti
               a clothespin the heart the clothespin was broken
A29          ((Jil and Pit are looking behind them as the teacher passes))
A30   Ann    ass e futti   [gaangen ënnert d'waasser
             got it broken [under the water
A31   Jil                  [jo
                           [yes
A32          jo an duerno ass och de härz uewe gaangen (-)
             yes and after that the heart floated (-)
             ((lifts hands in front of her face))
A33   Ann    ass de becher UEwe gebliwwen oder Ennen
             did the bowl stay on the top or the bottom
A34   Jil    <<upset>uoo::> ((lifts hands and turns head back and forth))
A35          ENne:=UE:[Wen
             DOwn:=U:p[ward
                      [((lifts hands and tumbles backwards))
A36   Ann    uewen an (.) o=och ënnen oder?=
             on the top and (.) o=on the bottom as well or?=
A37   Jil    =io (…) ((hugs Ann and turns away)) io
             =yes (…)                            yes
```

As Ann asks them "*and what else went under*" (line 23), Jil very expressively mentions a heart that had floated. Ann uses her position as the camera-holder and interviewer to produce a repair, i.e., an utterance that attempts to correct the problem. She interrupts Jil in line 27 with emphasis and points to the role of the wash

clip “*a clothespin a clothespin*.” Ann’s next question *“got it broken under the water”* (line 30) differs from the previous one (line 23). She is able to ask this rhetorical question only because she participated in the activity and can incorporate the answer into her question. Ann’s last question in this extract is a simple ‘yes-no’ question again, similar to the question if wood was swimming or not *“did the bowl stay on the top or the bottom”* (line 33). Jil struggles with this question and replies first *“down*” but then shouts out very loud *“upward.”* She skips backwards away a bit, and Ann recasts Jil’s answer into a new question *“or”* (line 36) to emphasise that the bowl could float and sink as well. This is finally affirmed by Jil.

Together, Jil and Ann construct a retelling of what happened with the heart that had first sunk to the bottom attached to the clothespin. After the ‘clothespin-heart construct’ had fallen into pieces under water, the heart came up to the surface (lines 27–31). Together the girls reconstruct the investigation they had with this heart, and Jil uses multimodal semiotic resources to express her ideas and experiences, particularly her body. She moves back and forth toward the camera-holder while jointly elaborating on their investigation The main structuring of this talk is done by Ann, who is in a specific position, holding the camera. So the tool (i.e., the camera) and the historicity (i.e., the local history of the event in the sense that the interviewer is a member of the peer group and participated in the prior investigations) mediate the way the children talk about their science learning experiences.

Extract B1

The present conversation takes place between three children, with two boys facing a girl holding the camera, and the teacher (Tea) who stands behind the girl recording the conversation (Sue). The boys (Ced, Dan) are telling the teacher about their unsuccessful experiment to build a ship out of plasticine (clay). Dan is using gestures to show how the plasticine was always sinking.

B22	Tea	wësst der awer net wéi dat gangen ass
		but don’t you know how that worked
B23	Ced	[nee
		[no
B24	Dan	[nee ((shaking head))
		[no
B25	Tea	wësst der och net wéi dat geet fir e schwammen ze loosen
		don’t you know either how it could be done to make it swim
B26		[hutt der keng idee
		[don’t you have any idea
B27	Dan	[nee=
		[no=
B28	Dan	nee (.)
		no (.)
B29	Ced	**nhnh**
B30	Dan	ne ((lifting shoulders and blowing up cheeks))
		no
B31		(2.0) ((boys are staring right on))

The present sequence starts with a rhetorical question of the teacher "*but don't you know how that worked*" (line 22). Given the negation and the fact that there is no rising intonation in her voice, we can gather that the teacher did not really expect an answer to her question, or simply a confirmation of her assumption. When she elaborates on her question in line 25 "*don't you know either how it could be done to make it swim*" she still keeps the negative design of the question and doesn't raise the intonation at the end. Her next turn in line 26 does not even have any feature of a question. It is rather a declarative statement, or assessment "*don't you have any idea.*" In this excerpt, the teacher is leading the conversation while the boys are keeping eye contact with her most of the time. It seems that the teacher's questions reflect both an assessment and a participation orientation. First, she is checking what the children already know about the water. Second, her questions appear to aim at keeping the children engaged in thinking about water issues and to express their thoughts. But, here her prompts do not achieve these aims and the conversation runs into a dead-end situation. It might be that the teacher's questions evoke interrelations between causes and effects of the phenomena that the children did not consider so far or that they did not imagine to be relevant to mention. It might also be that the teacher is emphasizing particular elements that are not aligned with the children's interest and they thus do not have an appropriate answer to the teacher's questions (lines 23–24). The repeated short negative answers and their body expressions display a reserved status and low enthusiasm to continue the talk. The boys do not seem to have anything relevant to say, but continue to keep eye contact with the teacher. Sue moves the camera alternatively to one or the other boy. She takes the role of an external documentarian, but is not intervening in the talk so far. In the extract below however, she joins in and revitalises the talk.

Extract B2

```
B32   Sue   war et da FLOTT? (1.3)
            was it GREAT?
B33         ((boys are gazing into the camera))
B34   Ced   jo[:o
            Ye[:es
B35   Dan     [jo: ((smiling))
              [yes
B36   Ced   ((nodds and comes closer to the camera, smiling))
            (2.0)
B37   Sue   a:nn? hu mer fl    (.) [schéi saache gema:ach?
            a:nd? did we do pl (.)  do nice things
B38   Dan                           [((smiles))
B39         [jo:
            [yes
B40   Ced   [jo:o ((moves face close to camera))
            [ye:es
B41   Dan   <<smiling> mir hunn ëmmer (.)
                       we have all the time
```

```
B42          [d' Cindy säi plastelIN geklaut>
             [stolen Cindy's plasticine
B43    Ced   [((moves face close to the camera))
B44          déi blo: alles an (.)
             the blue all and
B45    Dan   ((moves behind Ced to the other side))
B46    Ced   an dann de   [gringe gemaa:ch=
             and then the [green done
B47    Dan                [=krri hi= ((laughs))
B48          [jo
             [yes
B49    Ced   [an da war et   fuar[weg
             [and then it was colored
B50    Dan                       [weg
                                 lored
             (1.5)
B51    Sue   mm[hhh
B52    Dan     [eng säit war blo an eng säit war gri:ng
               [one side was blue and one side was green
B53    Tea   okay
B54    Ced   an d'waasser war(.)
             and the water was (.)
B55          war [eng säit=eh=blo an eng säit gring=
             was [one side ah_blue and one side green
B56              [((draws line with index and shows 2 sides with hand))
B57    Dan   =ech hunn schon dat gesot (.) (incompr.)
             =I have said that already
```

Now Sue, the girl with the camera, takes the lead and asks the boys. Her question “*was it GREAT?”* (line 31) introduces a new dimension in the talk, not mentioned so far, as this word refers to the entertaining side of the inquiry task and to the possibility that the kids enjoyed the activity. The way Sue asks the question is very different from the preceding teacher questions. First of all it is an open question; secondly, she stresses *“GREAT”* and finally, she has a clearly rising intonation. Here, the joint background of the three children, having experienced the same investigations, is spurring the question. Furthermore, she continues by *“an:d?”* (line 36), which opens the floor to the boys encouraging them to relate further what happened. Now, she also includes herself in the group and speaks about *“we,”* so that the talk shifts from a dialogic question-response format to a conversation.

Furthermore, she is no longer the external observer, but incites the boys to give an extended description about what was going on with the plasticine. The utterances about the colors of the water show richer details and a higher fluidity than in the prior teacher-led talk. They are also associated with iconic gestures, i.e., hand movements that delineate figural representations (line 56). We see in this extract that the format of the talk changes. There are more overlaps and the boys give evidence of their joyful experiences. They move and come closer to the camera – which can be seen as an indication of their engagement and excitement to tell about their experiences. Furthermore, the children repeat the experiences from their personal view, whereas this seems less relevant when they speak to the teacher. Furthermore, the speaker seems to matter here (line 57).

Extract C1

In the next sequence, the main teacher (Int) asks the same group of children (Ced, Dan, Sue) about their experiences during an experiment, where they could investigate the floating abilities of different objects. At the beginning, a boy (Ced) operates the camera. Later, the camera is passed to Sue (Extract C2) and, more importantly, the teacher leaves the room. This alters the way the children speak about their experience, which changes again when the teacher enters the room after a while. We are especially interested in these transition moments.

```
C01   Ced   allez
            go
            (2.0)
C02   Int   dajee
            come on
C03   Sue   okay e:hm .hm:=mä:r haten tEI: ge[ma:t mat waasser
            okay e:hm .hm:=we: had made tEA: [     with water
C04   Ced                                    [net téi;
                                             [not tea
C05   Dan   mir haten lo o:ch ëm sou becheren w:wat wat et schwëmmt,
            we had now a:lso mm such cups wh:at what is floating,
C06         oder oder geet ënnen an d=wasser ëmmer (--) sou mmh
            or or goes to the bottom of the water always (--)so mmh
C07         mär probéieren fir ze schwammen mee si ginn ne:t
            we try to float but they do not work
C08   Int   waat geet net
            what doesnt work
C09   Dan   ma=magnéit läffel:
            ma=magnet spoon:
C10   Sue   magnEIt hat och un der kä:erz geklamm::t (-)
            magnEt had also clamp::ed on the candle (-)
C11   Int   an huet de magnéit geschwomm=ass dee geschwommen
            and did the magnet float=was that (magnet) floating
C12   Dan   mm[hh
C13   Sue     [jo::o
              [ye::s
C14   Ced   ne:e
            no:o
C15   Sue   e war e bëssen esou geschowmmen
            it floated a little bit like that
C16         mä da waren awer bëschen ënnergaang
            but then it sank a little bit
```

The teacher interviews the children about their water experiments and structures the talk. In the first part of this excerpt C1, and even in the following section, she is asking an open question "*what did you want to try*" (line 42 below), three follow up question "*what does not work*" (line 08), "*was that (magnet) floating*" (line 11), "*how died"* (line 53 below) and utters one summarizing, rhetorical question "*ah yo = you wanted to keep all the things up"* (line 48 below).

```
C38   Int   [well t ass jo net drem gaang fir téi ze maan
             because it was not about making tea
C39         t ass drem gaang fir d'Kraaft
            it was about to … the power
C40         em wat ass et gaang=wat wollt der do man
            what was it about what did you want to do
C41   Sue   mer wollte=n:::ehf probéi:e[ren
            we wante::d::ehf   to try
C42   Int                              [wat wollt der probéieren
                                       [what did you want to try
C43   Sue   t ass et alles uewe blei()=
            that everything stays on top
C44         =mä d magnäI:t (.)
            =but the magnet (.)
C45         mh d magnéit war ëmmer ënner gaang[e:n=ele:ng
            mh the magnet went always down    [    alo:ne
                                              [((looks to dan and smiles))
C46   Dan                                     [io    leng
                                              [yes   lone
C47   Ced   <<laughs>ehehhe>
C48   Int   ah de=dir wollt d'saachen all uewen behaalen,
            ah yo=you wanted to keep all the things up
C49   Dan   [jo::o:
C50   Sue   [jo::o: (.) <<ironically>well soss wären se gestUerwen>
            [ye::es      if not they would have died
C51   Ced   [nä:: net gestuerwen  <<laughs>hihihi:::>
            [no:: not died        <<laughs>hihihi:::>
C52   Dan   [hihihi::: hihihi::
C53   Int    <<seriously>wéi gestuerwen>
                      how died
C54   Ced   [hehehe
C55   Sue   [mhmnm (asn) hiihii
C56   Dan   [hihihihi
            (2.0)
C57   Int   sou elo häls du=lo därf hien och nach schwätze gell
            so now you hold  now he can speak also ok
C58         hälls du s un   (--) d'kamera
            Will you hold it     the camera
```

In line 38–40, the teacher takes longer turns as she corrects the students and tells them what to do, or what the exercise is about. This clear teacher-talk can be an indication of the difficulties she has trying to make sense out of the children's talk. Especially the two playful aspects, the tea making (lines 38–40) and the keeping things up “*if not they would have died*” (line 50) seem to go against her own didactical idea about the children's main focus of investigation “*it was about to … the power*” (line 39). Nevertheless, she recasts her utterance and asks the children to explain their framework (line 40). The children emphasize their imaginative, playful and unconventional approach as regards the interplay of sense making and their investigation process. At the end, they seem to set this against the teacher's request when they affirm their view in unison *“ye::es”* (lines 49 and 50) or when all three children laugh (lines 54–56) about Sue's funny answer (line 50). This seems also a sign for the teacher to leave the conversation.

Extract C2

When the camera is handed over from the boy to the girl, the teacher leaves the room. From now on, the kids do not only manage the recording, but also the talk on their own. They keep up the interview style, but exagerate it when they present themselves. Thus, the way they engage in the interview is different.

```
C68   Sue   ech kann awer och schon esou dréinen ((turns around with the camera))
            but i can turn now like this as well
C69   Ced   moien ech sinn de ced
            hi i am ced
C70   Dan   ech sinn hei den <<laughs>(…) hellëge popst>
            i am here the <<laughs>(…) holy pope>
            ((standing up from couch))
C71   Sue   jo a=wat maacht der=wat hu mer gemaacht?
            yes an=what do you do=what did we do?
```

After a short discussion about who operates the camera and how "*but I can turn now like this as well*" (line 68) we see that the way the children talk in front of the camera changes. They begin by presenting themselves, "*hi I am Ced*" (line 69) which is done by Dan in form of a funny, ironic comment *"I am here the holy pope"* (line 70).

The next turn from Sue is very interesting with respect to the topic of children as researchers. She produces first in line 71 "*yes an=what do you do=*"but then quickly shifts to "*what did we do.*" This comment, produced at this place and in this way, could mean that Sue first took up the role of the interviewer that questions the others "*what do **you** do"* as the teacher did. But then she changes to a participant perspective "*what did **we** do*," as she was part of the group and the exploration activity.

This switch or distinction recalls the concept of we/they identity within language communities (Gumperz 1982). Whereas the we-code is "associated with in-group and informal activities" (1982, p. 66), the they-code is usually "associated with the more formal, stiffer and less personal out-group relations" (1982, p. 66). This point is crucial because it shows that children as participant observers are in the group and can help us to gain new insights that we are not able to obtain without their collaboration.

```
C72   Dan   de ced hat mir e becher geholl
            ced had taken a mug for me
C73         läffel ähm ähm ähm ähm(.) saachen (.)
            spoon ehm ehm ehm ehm     things
C74         dann ass et alles gefall(-)
            then everything fell down
C75         ausse:r puer sidd geschwomm[en
            except few that were floating
C76   Ced                              [an (.) an a mär
                                       [and    and a we
C77                                    [((raises hand and finger))
C78         [an dee gringen <<laughs>décken (.)
            [and the green          stubby one
C79   Dan   [a mär an ech a mä <<laughs>hehe>
            [and we and i and we
C80         [an dee gringen décken>
            [and the green stubby one
C81   Dan   [an ech
            [and i
C82   Sue   [<<laughs>hehe>
C83   Céd   an e gre e de gringen décken den hate mer geschoSS
            and a gre a the green stubby one we had thrown
            ((turns to door))
C84         a mer dann  [a plupp
            and we then [and plupp
C85                     [((straightens up))
C86         <<all>an dann hu sou: UA:AH: gemaach>
                  and then have yelled UAH:AH
C87   Dan   maach kee bloedsinn ced
            don't be stupid ced
```

We can see that the children continue their conversation about what happened during their workshop. When Ced takes the turn in line 77, he does this while raising his right hand with his forefinger pointing up. This is a typical gesture of a student who wants to give an answer. This gesture is part of discourse practices relevant in the school context, which the children are used to. However, afterwards Ced and the other child break out of the format and become much more lively, they produce more gestures and body movements. They are more engaged in retelling their experiences, with more overlaps (lines 78–82), a lot of laughter and body expressions until the teacher comes back. Dan realizes this first and switches immediately back to the previous format urging Ced “*don’t be stupid Ced*” (line 87). Sue also shifts back to the role of an interviewer (lines 91 and 96).

C88	Int	mach=maacht dir dommheeten do?
		are you being silly there?
C89	Ced	[ne:ee ((turned to door))
		[no
C90	Dan	[ne:ee
		[no
		(3.0)
C91	Sue	(da fuart=)
		(then contin incomprehensible)
C92	Int	=wou sinn die aner
		where are the others
C93	ced	=an an mir haten=mir haten probéiert ze
		and and we had=we had tried to
		((turns head from right to left))
C94		die saachen an d’lucht ze hiewen a magnéit war (.) drU:nner=
		lift up te things a magnet was (.) on that
		((moves to camera))
C95		=an déi ass net méi (.) LAss gaang
		and this did not go up anymore
C96	Sue	jo an du?
		yes and thereafter?
C97	Dan	an dann ass et de (.) de kaerz a magnéit
		and then it is the (.) candle and magnet
C98		<<p> gaangen (.) an sie waaren net gaa:ngen (-)
		went and they did not go
C99		dann ass et den mhm::mhm>
		then it is the mhm::mhm
C100	ced	an ech hat magnéit
		and i had magnet

The next turn from the teacher in line 88 “*are you being silly there*” is an admonishment and generates a synchronous negation from the children. Then the verbal interaction stops for about 3 s and it is Sue who encourages the boys to continue (line 91). In the next turn from Ced, we can clearly see how the format of the talk immediately shifts back to formal classroom talk and how his gestural production diminishes. Sue’s follow up question (line 96) about something that she probably knows, encourages the boys to elaborate their acting further for the purpose of the recording. This emphasizes the meta-knowledge that the children develop when handling the recordings by their own.

What Learning Happened?

An important element of our research activities was to enable children to play an active part in the construction of their knowledge about natural, physical and chemical qualities of water, both by manipulating everyday equipment in open workshops and by exchanging their views within their inquiry groups. The children manage to handle the portable cameras without any problems. They document their investigations and conversations through video- or photographic recordings. These recordings make their perspectives and meanings apparent. Furthermore, the data can be discussed with peers, teachers, student teachers, researchers and parents.

During their conversations, the children exhibit a playful, emotional and highly expressive way of talking when they refer to and make sense of what they experienced in the preceding phase of exploration. They express their ideas through multimodal discourse repertoires and formats, using a lot of gestures, body movements, speech overlaps and paralinguistic features. Although their expressions are sometimes quite unconventional as they dance or tease their ideas into being, their talk however is staying on the science topic all the time. The auto-recorded data and derived transcripts give us important information about their understandings and meaning making processes. However, these creative elements are less visible as soon as the teacher joins the talk. Moreover, she mostly structures the talk by drawing upon conventional classroom discourse tools using formal questions or directives. The children answer in the usual formal way, as they are used to do in classroom talk. The funny and unconventional moments of their joint investigation sessions are kept out of the teacher's sight.

The children also give us insights about their participation frameworks (Goodwin 2003) that they invent to create shared meaning of their interesting explorations, e.g., making tea within a floating-sinking workshop or trying to keep all objects at the surface to prevent them from drowning. The teacher experiences difficulties to understand these playful elements and imaginative frameworks as a serious inquiry process within 'doing science.' Nevertheless, these contributions mediate sense-making investigations about the properties of water.

Here, the lack of shared experience between the teacher and the children is of critical importance. As the teacher did not participate in the children's imaginative ways of exploring water phenomena, she cannot refer to these shared experiences and sense making dimensions in her conversation with the children. She is caught in her didactical framework that spurs the question-answer sequences and which does not produce an 'in-between zone' with the children's framework.

The child that operates the camera has an important role in structuring the talk. As a participant of the former experiences she often raises questions that can only be asked when drawing upon a shared fund of experiences. The camera holder never shows difficulties about handling the technical aspect of the camera, although it is the first time students use this equipment in the school context. However, they display a large meta-awareness about the recording process itself and recurrently stimulate their peers to elaborate further details or specifically funny elements of the joint acting for the documentation purpose.

Children as co-inquirers are not just producing valuable data, but are also generating a more elaborated and qualitative knowing in their co-operative inquiries. For Park (2006) this knowing will be more valid if different ways of knowing are congruent with each other, i.e., "if our knowing is grounded in our experience, expressed through our stories and images, understood through theories which make sense to us, and expressed in worthwhile action in our lives" (p. 183f.). Especially, when children are making sense of their prior investigations in describing and discussing them in front of the camera, the verbal and non-verbal symbols, metaphors and analogies they use have to be considered as significant means "to ground descriptive and explanatory propositional knowing more fully in what has gone in the prior action phase" (Park 2006, p. 184). Furthermore, these means have to be related to the contexts where they refer to or seem to stem from.

The Boundary Zone as Change Agent

According to the depicted activity theoretical framework at the beginning of this chapter, we want to direct our attention towards the 'emergent zone', where elements from two activity systems, i.e., educational research and pedagogical practices, enter into contact and generate opportunities for mutual learning and development. Children only rarely have this role as co-inquirers within Luxembourgish schools. This innovative and enriching practice emerges in the jointly created 'in-between-doing-science-zone', where exchange and negotiation between participants with different backgrounds and viewpoints take place. The impact of the children's conversations has been largely evidenced in the present chapter. Developmental processes did not occur at the individual level only, but at the collective level as well. The teacher team quickly acknowledged the potential of the children's auto-recordings for understanding their knowledge building processes about water phenomena. The teachers watched the data, alone and together with the researchers, and reflected upon the design of the next activities to implement. Prominent utterances of the children's conversations were selected for being discussed with all the children. The science workshops were initiated by the teachers and researchers, but were later on co-constructed with all the participants and on the basis of recorded data. The research activities of the children shaped and were shaped by the learning context or the 'doing of science' as interactional achievement. Stimulating elements also crossed the science classroom borders to enter the research context and the overall school context. Given the quality and richness of the children's data, our research team has decided to give this topic greater emphasis in upcoming research projects. The teachers saw the potential of the recordings for evaluating the children's competence development. In particular, the easy making of the recordings and the children's technical skills pushed the teachers to use this kind of documentation more often in their practice. As the cameras are not expensive, teachers already planned to buy these tools for their school equipment. From the data we have analyzed, we can clearly see that the children and the teachers managed to co-create a joyful and enriching experience and benefitted from the opportunities for learning and development.

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Chapter 8
Social, Cultural and Emotional Contexts of Transformative Learning Environments

Cristobal Carambo

The academic underachievement of children from minority populations remains a central focus of the national discourse on equity in public education. The efforts to "Leave No Child Behind" have however, continued to focus on the institutional components of teaching and learning, such as standardized curricula (Wright et al. 1997), teacher "best practices" (Sanders and Rivers 1996), and achievement on high stakes assessments (Sanders and Horn 1995), as the sole means to effect equitable educational opportunity (McNeil et al. 2008). In science education research, curriculum experts continue to dwell on how to effectively teach discrete science concepts or on ways to ameliorate students' "misconceptions" of canonical science content. These efforts, while well-intentioned, are theoretically underpowered as they are informed by a theoretic that views learning as individualized rationalistic activity. Moreover, these reform initiatives fail to acknowledge the reality that inner city communities have been marginalized and impoverished by political and economic policies (Wilson 2007) that have severely limited their ability to adequately fund their educational institutions (Orfield and Lee 2005).

In this chapter I propose that efforts to provide equitable educational opportunity to children from minority populations must first begin with an understanding of the social, cultural, and historical factors that contextualize schooling in our nation's inner cities. Our work in the Philadelphia Public Schools (Carambo 2009) and in the NYC Public Schools (Bayne 2009) has shown that an understanding of the sociocultural dimensions of teaching | learning[1] provides educators the theoretical

[1] The Scheffer stroke (|) is used throughout this paper to denote dialectical relationships. Dialectical relationships juxtapose perspectives, actions, or concepts that mutually presuppose and / or constitute each other (Roth 2005). While the constructs in a dialectical relationship may seem contradictory or independent of one another, they cannot be fully conceptualized in isolation for they are each part of a dynamic process that unifies the two entities into a more comprehensive whole that promotes ongoing development and change (Tobin and Roth 2000).

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insights and methodological tools needed to create learning environments that maximize the learning potential of children from traditionally marginalized populations. Central to our perspective is the belief that teaching | learning are collective social activities (Vygotsky 1978) unfolding in communities of practice (Lave and Wenger 1991). Thus learning science is not merely the accumulation of facts and cognitive skills, rather learning is viewed as a process in which students are socialized into the school science community with its particular set of social practices and related schema (Lemke 2001). As such, sociocultural perspectives on learning focus on the intersection between identity (as an affiliation with a community of practice) and the social cultural contexts in which that identity is formed (Faircloth 2012).

Sociocultural perspectives are essential to our work because the cultural perspectives of students (and parents) from marginalized populations may differ in many respects from the dominant cultural themes that inform the educational institutions and the life narratives of teachers and administrators (Norman et al. 2001). The urban classroom is *necessarily* populated with boundaries of difference that often become sites of contestation and tension as teachers and students attempt to communicate across difference (Tobin 2006). Sociocultural perspectives provide the methodologies needed to successfully communicate | negotiate across cultural boundaries and in so doing create learning environments characterized by trust and mutual respect (Martin 2005). Within these environments, students are able to engage in successful social interactions that foster positive emotional energy and feelings of membership (a successful identity) with the school science community (Olitsky 2004). When this occurs students are *willing* to fully deploy their stores of social, symbolic and cultural capital to learn science in ways that are relevant, personally meaningful and transformative in their lives (Pitts 2007).

In this chapter, I write from the perspective of a teacher-educator who has worked in urban science for over 18 years. I present two stories from my research in an urban high school in Philadelphia to support the use of sociocultural perspectives as the guiding theoretic in my work as educator – researchers. Each story highlights a different component of the cultural sociological perspectives that have facilitated the creation of successful school science identities.

The first story "An argument with Ya-Meer," highlights the role that cogenerative dialogues have on the resolution of contradictions in the classroom field. The resolution of the argument demonstrates how genuine communication | negotiation across difference provides students (and teachers) the interstitial space to (re) create cultural identities. As a result of the "argument," Ya-Meer and I were able to reestablish an amicable relationship and he was able to successfully complete his senior year. He would graduate the following year as one of the highest achieving students in our learning community.

The second story: "Matthew and the electric motor," illustrates what occurs when students experience a chain of successful social interactions that foster positive emotional energy. Before engaging in his project, Matthew's academic history was such that he was failing most of his major courses and was in danger of not graduating with his class. The identity he created while exploring electromagnetism gave him the confidence to alter that history. During his senior year, he took additional classes

in our twilight program, where he made up sufficient credits to graduate with his peers. Matthew's story is particularly salient as he represents what is possible when students with a history of academic underperformance are able to access all of the structural resources in the classroom field and thereby maximize their learning potential. His motor project remains as one of the more successful science projects of any student in City High school.

The Argument with Ya-Meer

Environmental Science Class: October 2001

Ya-Meer, a student in my 11th grade environmental science class, was one of the better achieving students in our learning community. He was a slightly built young man, with glasses and a quick smile, who was well liked by students and teachers alike. I had met him in the fall of 2000 and we had established a cordial, respectful relationship. Our science class was generally orderly and responsive to my instruction, as I had earned a good deal of respect among the students during the previous year's teaching. I was therefore very surprised when a loud contentious argument broke out between Ya-Meer and me.

The Argument

The argument began as I returned graded tests on the effect of pollutants in the environment. Charles, who had a history of average achievement, had earned a 93 %. I congratulated him openly on his accomplishment and continued handing back papers. Ya-Meer upon receiving his paper asked, "How'd I get an 83?" I told him that I would review his grade towards the end of class. When I reviewed the grades, I realized that I had made an error: Ya-Meer's grade was in fact a 65: the 83 was another student's test grade. Ya-Meer grew quite angry and shouted "How'd I get a 65"? Although I was sympathetic to his feelings, I told him that I would not respond to him if he continued to shout at me. He quieted down and we proceeded to look over the test. Out of five answers, he had answered only two completely right: had earned partial credit on two others and had missed the fifth. Ya-Meer could not understand why he had received partial credit for his answers. I tried to explain that his responses were not adequately supported with concepts we had studied in class. Ya-Meer however, would not agree with my evaluation of his answers and continued to insist that he could not have gotten such a low grade. I attempted to explain my reasoning once again, however we could not resolve the issue. Our inability to communicate frustrated (and angered) us. At one point, he became quite angry and started to shout once again. I had not had a student publicly disrespect me in a very long time, thus as his anger grew so did mine. The

ensuing argument lasted for several minutes when Ya-Meer suddenly shouted, "Man I don't want to hear any more from you" and stormed out of the room. I followed him into the hall as leaving the classroom without permission was a serious infraction in our learning community. In the hall, he yelled at me once more and would not return to class. By the time class had ended, Ya-Meer had been located and was sitting in our coordinator's office. I had calmed down and once again attempted to discuss the grade with him. My attempts were fruitless as he was still convinced the grade should be higher: we began to argue once again. Our coordinator was unable to broker a compromise as each of us had hardened our positions. Ya-Meer felt that my refusal to reconsider his grade was evidence that "You teachers always want to be right." I felt that he was being overly obstinate and said, "I can't talk to him any more; he's crazy." I then left the room.

Cogenerating Solutions

Fortunately, events did not end with this first day's impasse. The next day we met briefly in our coordinator's office. We apologized to each other and decided to use our learning community's resources to find a solution to the problem. During the next several days, Ya-Meer engaged in cogenerative dialogues with two student teachers, and a university researcher. Through his ongoing dialogues, he was able to clarify and articulate (both to himself and to others in our community) his perspectives on the incident. During that time I too was able to reconsider my actions in the event and, through discussions with co-researchers, was able to understand Ya-Meer's perspectives on the events in our classroom. A few days later, we met once again in the coordinator's office and had our own cogenerative dialogue. Although we had known each other for over a year, we had never spoken of our personal histories, of our families, or our goals as members of the SET small learning community.

As Ya-Meer spoke about his family, his history as student, and his aspirations to be a "straight A" student, I realized that I had failed to fully appreciate his biographical narrative, nor had I fully understood how important his grades were to his emerging identity as one of our community's highest achieving students. In retrospect, I understood that the incident could have been avoided had I realized how important (and fragile) his identity was to his agency as a student. I would learn later that it is our historical biographies, (and our emerging sense of self), that inform the internal subjective narratives that we use to order and structure our experiences (Roth et al. 2002).

> Frequently these narratives articulate the environment that [we] experience as enabling or constraining individual agency. These narratives, which are used to sustain self-identity, are *inherently fragile*, for they have to be created and continually reordered against the backdrop of new and changing experiences of everyday life and in a context of individuals participating in numerous fields, experiences that tend to fragment perceptions of the self (p. 9).

As I listened to Ya-Meer I grew to understand the cause of our altercation and how my actions had occasioned the anger that so quickly overtook the classroom. The catalyst to the event was my inaccurate grading and failure to correctly identify his test paper. This communicated a lack of esteem and inattention to his talents and motivations as a student. Although the altercation was initially destabilizing, our cogenerative dialogues provided a field wherein we could talk freely in a space free of official hierarchies or power differentials. The following excerpts of our dialogue are taken from the research paper, *Remaking identities in the praxis of urban schooling: A cultural historical perspective,* (Roth et al. 2002).

Ya-Meer:

> *From my end of the situation: Like the only reason why, I just got mad because it wasn't my paper that you read off your sheet. But then when you told me that I had the sixty-five. The reason why it made me mad is this is my last year; I want to get straight A's. And the sixty-five won't help me out at all. So I was mad more with myself than with you. And my first reaction was, "How did I get a sixty-five?" I was still mad; I wasn't really hearing you. I wasn't listening to you while you was talkin'. But I was listening to you a little bit, like when you say, let's go over it; you started to read the question, where I had the most points off. And I answered the question the way I thought you wanted it but it wasn't good enough.*

Cristobal:

> I realized when we had that conversation that I said to you, "What did I do to get you so angry?" and you said that I wasn't clear about the grade. And part of me thought, "you know he's right," and then I realized that's where a little bit of disrespect happens because when you first asked me about the grade and I said eighty three then sixty five, I didn't really care, because to me grades are not so important. But what was disrespectful to you was not realizing how important grades are to someone trying to get all A's. So I didn't take into account that the sixty-five might have shocked you and I should have been more careful. And so the fact that you are trying to remake yourself as a straight A student, and you are looking at the grades and I don't care about grades … that is where the disrespect comes in. Because you don't realize how important these things are to other people."

Reflecting on the event, I came to understand just how demeaning the low grade was to Ya-Meer's identity as a high achieving student. Listening to his version of events clearly identified the contradictions in the classroom field, which made him feel disrespected. Once disrespect breached the classroom field, communication was no longer possible and negative emotional energy flooded the learning environment.

Ya-Meer:

> *Respect is the most important thing in what happens here at school. A lot of times students would disrespect teachers because they have problems … they just be having problems… that they can't express to teachers… that they don't feel right showing teachers… like they got a problem at home that is stressing them out, and the teacher don't know what that problem is like for the student…. So, like if I got a problem at home and I put my head down and you come over to me and tell to put my head up. I would think that you bothering me. And I would just start flipping. Just because of my situation at home. And that would be like disrespect to the teacher but the teacher doesn't know much about what happened at home. So people bring situations outside a school to school and they just offend the teachers. And a lot of times teachers got so many students at one time… and sometimes teachers don't care about students. A student can do one thing that teachers don't care about. And that teacher would think that student is disrespecting them and they go off too.*

Cristobal:

*That is true. Especially in our community where kids have such hard times without us realizing it. A lot of times it is in the morning when they tell me, "Get the f*** out of here." And all you did was to say, "Put your coat away." That response comes from something that they had coming out of their life. And sometimes the teacher is worried about the lesson, something going on in school or in their own lives, and then they don't have the time, or can't take the time to take that little step to find out what is going on with kids.... and if a student is having problems and disrespects the teacher… then the teacher will say, "Oh Yeah? Let's go. You are out of here!" The other kids know what's going on and this creates a feeling in the class that we don't care about you, and the kid next to him sees that. And the next time they have a problem, they just flip right away.*

The argument with Ya-Meer provided critical insights into the effects that emotional energy and identity formation have on the learning environment. The contradictions in the classroom field fractured our cultural identities and occasioned the intrusion of negative emotional energy. Our actions during the argument further destabilized our solidarity with our school community as we each enacted culture from fields outside of the classroom. Fortunately, our cogenerative dialogues provided resources that helped us communicate across difference and reestablish a positive emotional climate. Most importantly, Ya-Meer was able to reaffirm his emergent identity as a high achieving student. He was able to successfully complete our science class and graduate with one of the highest grade point average in our learning community.

It is important to note that exemplary science learning requires a high degree of motivation and engagement with the curriculum. While the teacher can design a well-structured science lesson and provide access to requisite structural resources, it is finally the student who determines the level of personal commitment to his / her learning. A successful school science identity (as an affiliation with the schema and discursive practices of the school community) is therefore essential to our efforts to fully engage students in their learning.

Successful School Science Identity

Identity can be broadly defined as "our sense of who we are, our place in the world and our perception of how others see us" (Brickhouse and Potter 2001, p. 966). Our identities are informed by our membership within given communities of practice and the efficacy of our engagement with significant others within those communities. Membership in a community occurs when we (subjectively) align ourselves with the culture (the dispositions and practices) of a community and engage in meaningful goal oriented activity with the members of that community (Lemke 2001). As such, successful school science identities are critical to our efforts to provide transformative educational opportunity because they indicate the degree to which students subjectively align themselves with the culture of the school and of the scientific community (Brickhouse et al. 2000)

> In other words, to understand learning in science, we need to know much more than whether students have learned the proper explanation for how plants make their food or why there are seasons. We need to know how students are engaging in science and how this is related to who they think they are, (what communities of practice they participate in), e.g., a good student, a basketball player, a gossip, and who they want to be, (what communities of practice they aspire to): As students transform their identities, the requisite knowledge and skills for being a part of the new communities are learned. Thus, if students are to learn science, they must develop identities compatible with scientific identities (p. 443).

Historical and Emergent Identity

Identity consists of two differing and complementary aspects of the self: a historical (fixed) autobiographical narrative; and a provisional emergent identity that together provide the mechanism for the continued evolution of the self (Olitsky 2004). Our historical biographical narrative provides the schema (our internal voice) through which we analyze and reflect on our experiences and activity within our communities of practice (Archer 2003). In this manner, our historical narratives help order and maintain our stable 'sense of self'. Though we all have a sense of a stable fixed biographical self, it is necessary to note that the identity of an individual is

> not something that can be taken for granted as an a priori of activity, but is something that is made and remade as activity is enacted and when individuals participate in multiple activity systems (Roth et al. 2002, p. 7).

As we engage in cultural activity, we access relevant schema to appropriate requisite resources and pursue our goals. If there is coherence between our schema (our historical identities) and the structures of the classroom field, then participants are able to engage in successful social interactions that foster positive emotional energy and approbate their emerging identity. In such instances, students are able to fully deploy their stores of capital to learn in ways that deepen their affiliation with the culture of the school science community.

If however, contradictions exist, then agency is truncated and the boundaries of the classroom field are breached as participants enact culture that will help them achieve their goals. When this happens, students are no longer committed to the culture of the school community as they are reacting to events in the classroom that question their emerging identities. When this occurs, cultural boundaries harden, communication | negotiation across difference becomes impossible and negative emotions flood the classroom. This is often the case in urban schools when students disrupt the learning environment or when teachers enact symbolically violent culture, (which is equally disruptive) because students' sense of self has been disrespected.

If one's perception of self is not affirmed thence an incongruity between expectation and experience occurs: in such instances negative emotions (anger, fear, or sadness) result. These "emotions are markers or a sign that a particular identity,

which an individual expects to confirm, has not received such confirming responses" (Turner 1999, p. 144). Thus, the "activation of negative or positive emotions is related to whether or not anticipated confirmations of relative status or power have been realized" (ibid).

Reflecting on the argument between Ya-Meer and me, I could see that our actions had called into question the cultural identities we were so carefully constructing. In our cogenerative dialogues, we would each discover that the assault on our nascent identities activated the negative emotions that fueled our disagreement.

Within an environment characterized by negative emotions, students are not able to engage in social interactions that increase their sense of membership in the school science community. The negative emotional energy they experience promotes listless, perfunctory activity and an unwillingness to fully engage in cooperative social activity (Collins 2004). Such disengagement with the culture of school community is evidenced by inattention in class, incomplete (or missing) assignments, excessive absences, and (subsequently) low or failing grades. Analysis of activity in my science classroom revealed that some students were unsuccessful because the learning environment did not provide them the resources they needed to build a successful school science identity (Scantlebury 2005). These students failed to fully identify with our community and as a result, they failed to maximize their learning potential.

Close analysis of my students as they explored organic chemistry at the University of Pennsylvania (The Labs at Penn, (Carambo 2005)), and as they engaged in our end of year inquiry activities (The May projects 2002 (Carambo 2005)), provide evidence that exemplary learning occurred because the students experienced successful social interactions that fostered a positive emotional climate. The positive energy helped them construct successful science identities that supported their exemplary learning. Watching the videos of students in these environments, one notices many instances of humor as they learn. Pierre the "gangsta" chemist shows us how to make "deadly soap" with the many secret materials in the lab; the comments between Jarvis and his classmates as they expertly dissected the frog heart and the many lighthearted jokes between students and teachers evidence the positive emotional tone in the classroom. The positive emotional climate facilitated successful social interactions that helped students build science identities (Elmesky and Seiler 2007) and experience solidarity with the school science community (Olitsky 2007). It is the positive emotional energy and resulting solidarity with the culture of the school science community that (in my estimation) accounts for the transformative learning occurring within these alternate learning environments.

The May Projects 2003 continued out research into the relationship between positive social interactions and the creation of successful school science identity. Specific attention was given to students with a history of poor academic achievement. One such student was Matthew, whose lack of solidarity with the culture of our science classroom was evidenced by his many absences, failure to complete required assignments, and low test scores. He had failed the first grading period of our chemistry class and was in danger of failing the second grading period and the year.

Matthew's motor project was a collaboration with Ian Stith our physics teacher, Scott Koehler the mathematics / engineering teacher, Robert Price (the auto mechanics teacher in another learning community) and me as the chemistry teacher. An analysis of the video-documentation of his project (Carambo 2011) provides evidence of a chain of successful interactions and growing solidarity with the school science community. Matthew's work on his motor project was a stark reversal of his traditional lack of engagement and interest in learning. He would be present each day from May 28 through the end of school year. He worked diligently each day in class and stayed after school on three occasions to work on his projects. He attended two additional classes with the auto mechanics teacher, and one with our engineering instructor. His interactions with his mentor teacher allowed him more time to consider new information, discover new thoughts and interests, and (more importantly), ask questions in a safe, supportive environment. It was the emergence of this interstitial learning environment co-constructed by Matthew and his teacher that helped him forge a successful science identity and experience solidarity with the school science community (Gutierrez et al. 1999). As a result, one sees an increase in positive emotional energy (joy, satisfaction, enthusiasm for learning) throughout the eight-day project.

Emotional Energy and Collective Social Activity

Positive emotions (and the resulting positive emotional climate) are important to our work in urban schools because positive emotions promote feelings of membership and solidarity with the practices of a given community, while negative emotions tend to fracture solidarity and foster alienation from the work of the group. Positive emotions energize students and foster feelings of solidarity and commitment to the culture of the school science community (Olitsky 2007). They provide the energy "for physical activity [and] for taking the initiative in social interaction and putting enthusiasm into it" (Collins 2004, p. 107). Negative emotions reduce the level of activity, and produce social interactions that are perfunctory, listless, and passive. Negative emotions are especially damaging within the urban science classroom as they problematize negotiation | communication across difference and destabilize feelings of solidarity with the culture of the school science community. Successful social interactions promote solidarity because people are drawn to social encounters that foster positive feelings about the self (Goffman 1967) and one's membership in a given community of practice. Successful interactions generate feelings of satisfaction, joy, (and competence) which affirm the students' sense of belonging and increase (and sustain) their desire to engage in the ongoing work of the group (Olitsky 2007). Ongoing successful interactions will deepen a student's self – perception (his / her identity) as a member of the school science community. It is this subjective identification with the culture of the school science community that encourages students to deploy all of their stores of capital in the learning of science.

Parameters of Successful Whole Group Interaction

Collins (2004) informs us that feelings of membership are the result of successful social interactions that produce positive emotional energy. As the positive energy increases, it engenders feelings of solidarity with the collective activity of the group. The feelings of group solidarity in turn foster positive emotions: thus, positive emotions and solidarity are both "ingredients and outcomes of successful social interactions" (p. 35). Successful interactions are structured by four factors: bodily co-presence, synchrony of bodily rhythms, a mutual focus of attention, and a shared emotional mood. The degree of success on any interaction varies with the intensity of these parameters (Collins 1993), which together foster either, a positive or negative emotional climate.

The following vignettes span the scope of Matthew's project, which began on May 28, 2003 and finished on June 6, 2003. The tapes document his successful interaction with his teachers, the emergence of his successful school science identity and his solidarity with the culture of the science community.

MATTHEW'S MOTOR Project

Day Two May 29th 2003

We began the project with a whole class cogenerative dialogue as was customary to engage student voices and create a sense of co-participation in the creation of the curriculum. The first day of the projects was devoted to discussing possible topics and establishing the guidelines for each project (Fig. 8.1).

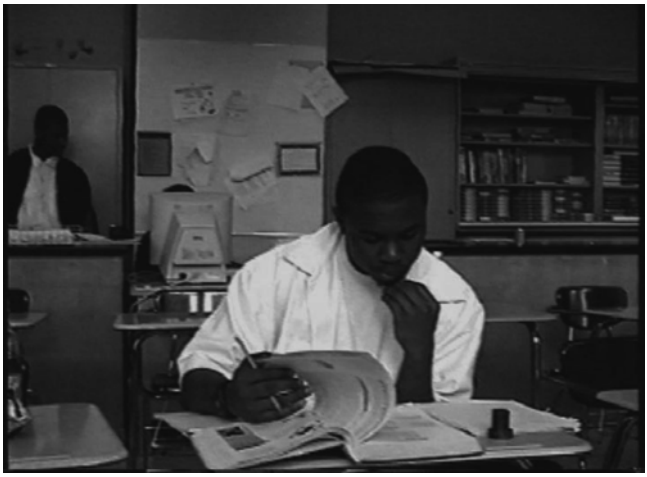

Fig. 8.1 Matthew explores the physics book for topics

On this the second day of his project, Matthew is seated at his desk looking through a physics textbook. Although he has chosen to explore how a coil gun works, he is unsure where to start. He leafs through the pages of a book looking for information. Ian notices his quandary and suggests that he might begin with a few experiments on magnets.

1:07:13 8.	Ian	Interrupting Matthew	Matthew?
1:08:18	Matthew stops reading, looks up, establishes eye contact with Ian		
1:08: 12	Ian	Continuing	Along with what you said before, since you want to make a coil gun, you could also do like some kind of smaller experiment for each of the parts, like some experiment that goes along with magnets, some experiment that goes along with electromagnets, and then the coil gun
1:28:06	Matthew	Unsure of what to ask	What kind of experiment could I have with regular magnets?
1:33:10	Ian	Pausing slightly	Well… I mean something real simple, basically
1:37:25	Keisha	Joining in	Just how things stick together
1:39:09	Ian	Continuing	Yeah, just do different things to see what's magnetic, what's not magnetic, then think about why, just simple activities, think about why things are magnetic, why things are not.
1:53:24	Matthew considers Ian's suggestions for a few moments. He then formulates a plan of study		
2:00:18	Matthew	As he writes down his plan	All right, learn about magnets, how do they attract, that they're attracted to, how they attract…
			(Remembering an important fact, he carefully note), Opposites attract.

This opening interchange is important to the ensuing relationship, as Matthew is very tentative and unsure of how to proceed with his project. Ian sensing this carefully interrupts and suggests a few ideas that will help create Matthew's learning space. It is important to note that Ian provides some resources for the exploration, but does not impose his notions on Matthew. Rather, (this will occur throughout the project) he allows Matthew to contribute to his learning in ways that allow him to deploy his cultural capital as an equal co-participant in the learning environment. In this way, the two create the interstitial space in which respect and trust are continually co-constructed (Pitts 2007). The relationship between Ian (a white, middle class, first year teacher) and Matthew (an African American student from an inner city urban neighborhood) illustrates the cultural alignment needed to co create transformative learning environments. Although the two represent two distinctly different cultural narratives, the resources within their learning environment allow each to fully deploy their stores of capital in a space "devoid of assumed or imposed hierarchies" (Bhabha 1994, p. 45).

This relationship will provide Matthew a space in which he can ask questions, look for answers, and be able to say "I don't know" without experiencing the symbolic violence that students often feel as they learn difficult science concepts. As the days progress, his increasing knowledge, self-confidence and successful cultural production will engender an increasing positive emotional energy and solidarity with the school science community. It is the combination of these interstitial cultural resources that provides the foundation for the learning environment within which Matthew will develop his identity as a successful science student.

Day Three: May 30 2003 (Fig. 8.2)

Ian and Matthew converse at one of the classroom laboratory tables. Ian is sitting cross-legged on the table: Matthew sits on a lab bench. The conversation is very relaxed as they discuss what electrons have to do with magnetism. Matthew posed the question as part of his research, but he has been unable to find a reasonable answer. Using the metallic base on the laboratory table as a resource Ian illustrates how the movement of electrons can temporarily polarize substances. As Ian speaks, Matthew also places his hands on the metallic base, nodding in agreement during Ian's explanation. They will both use the base as a mutual focus of attention. During the ensuing discussion, Ian continues to use the metallic base to demonstrate the polarizing of metallic objects (Fig. 8.3).

Fig. 8.2 "So if you touch it here"

Fig. 8.3 Matthew illustrating how to magnetize a piece of metal

1:28:29	Ian	Focusing the attention on the metallic base	Then whatever side it is, that you're touching
1:30:02	Matthew keeps both hands on the base, while maintaining eye contact with Ian		
1:32:29	Ian	Tapping the base with his hands	Let's say it's the positive side, …
1:34:16	Matthew signals he understands as he focuses his gaze on the metallic base		
1:35:09	Ian	Questioning Matthew directly	It's going to attract, what?
1:37:13	Matthew	Not sure of the correct answer	It's going to attract the … it's going to attract the… not the electrons…
1:43:04	Ian	In a soft voice	Yeah the electrons
1:44:11	Matthew	Looking at Ian directly. Surprised at the answer.	It's going to attract the electrons?
1:45:18	Ian	Correcting Matthew	Yes, the electrons… the electrons have a negative charge.
1:46:01	Matthew	Overlapping Ian's response	I do know that if you took a piece of metal that wasn't magnetic
	Matthew	Illustrating the movement with his hands	And you rub a magnet up against it like this way, it'll take the electrons and line them up so then therefore that metal will become magnetized

The notion that electrons are "lined up" by an external magnetic field is an oversimplification of magnetic phenomena however, it is important to the success of this interaction that Matthew feels comfortable enough to contribute his cultural capital to the discussion. Although his notions are not correct, they will gain in sophistication as he learns more about ferromagnetic materials, magnetic domains and electron spin. Ian does not correct Matthew's ideas in a manner that might discourage

or shut him down, rather he continues the discussion of how electron flow creates temporary polarity in metals as it is a good opportunity to illustrate how the movement of electrons affects everyday phenomena such as static electricity and lightning.

Day Four June 2 – Day Six June 4 2003: Increasing Social and Cultural Capital

On these days, Matthew visits Mr. Price's classroom in the auto shop. In Mr. Price's class, he had access to a wide array of metals, metal cutters, wires, and power supplies. He was able to create his most efficient electromagnets. It is at this point that Matthew gains independence from his teachers, as he will work by himself for the remaining days of his project. He is most eager to build a motor as part of his display for the class.

Day Seven: June 5 2003: Successful Motor Project

It is late in the afternoon on one of the last days of the school year. The class has emptied as the majority of the students in my chemistry class have completed their end of year projects. Matthew however has remained behind: he is still working on his project to build an electric motor. This is his third try: as his previous models have all failed. He reshapes the coil of wire that serves as his armature as it does not sit correctly on the contact points. He discovers an error in his wiring.

00.27:14 Matthew: "Oh, that's why it ain't working." He adjusts the clips, cleans the contact points, rechecks everything, and turns on the power (Fig. 8.4).

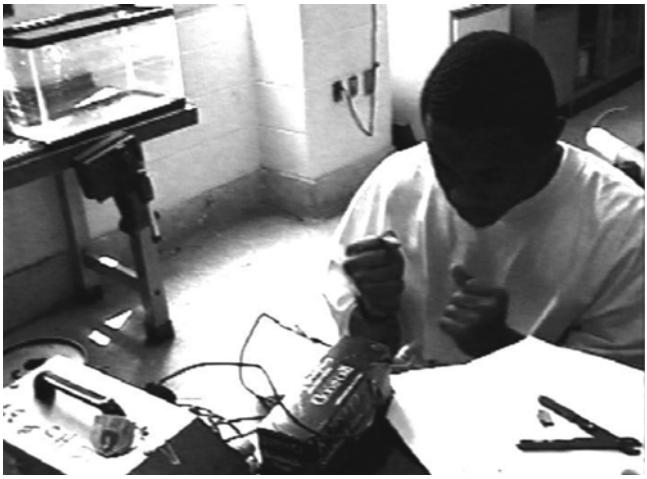

Fig. 8.4 "Yes"!

2.14:04 The coil of wire spins: he raises two clenched fists in a gesture of success. A silent, private "Yes" communicates the pride in his accomplishment. His success however, is short lived as the motor stalls. He pauses for a moment, then confidently re-adjust his connections, re-checks the circuit and voltage settings. He turns on the power and the coil begins to spin freely.

3.17.20. "There it goes," the motor works but the motion is halting. It stops and starts in bursts of motion: the motion is not continuous. Matthew has stayed after his regular class time because he feels he is close to success. Although his previous attempts have not succeeded, this day may prove different. He continues to adjust his setup (Fig. 8.5).

4.11.23 The motor achieves a continuous steady spin. He gives a slight celebratory dance moving his shoulders about.

4:14.25 He looks up (toward an unseen audience) and gestures to his work "See that?" He watches the spinning coil for several seconds, smiles, and remarks to himself:

4.18.25 "That's decent." He beams a broad smile of contentment.

4.23.23 He looks up at us, smiles, and points once again to his accomplishment. His look conveys self-satisfaction and pride in his intelligence.

4:24.07 "That's decent. Yo! I did it!" He raises the voltage to the circuit.

4:31:02 His voice rises in surprise. "It can go faster!"

4:41:04 The motor continues to spin efficiently: "That's decent."

4: 57:34 Sparks begin to fly, wires are overheating: the voltage is too high. He lowers the current, and sets the motor to work again. I am at the far end of the room: Ian the other co teacher is nearby. He calls out to us:

5:06.44 "Hey I worked it. I finished it."

Ian and I walk over to his workstation: the motor continues to spin efficiently. We are all extremely happy with his accomplishment, as he has worked diligently to

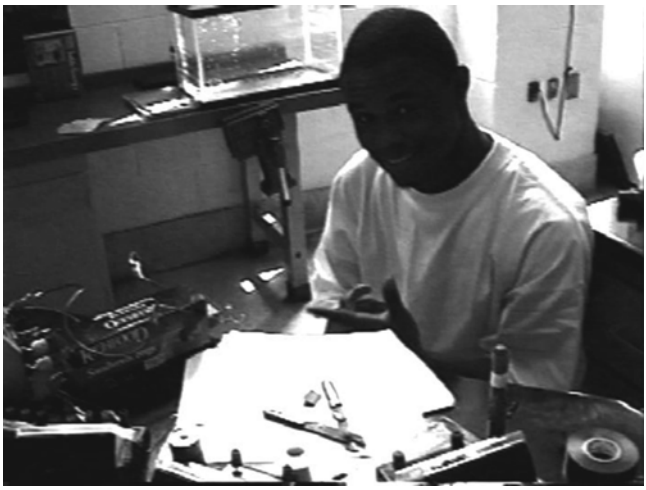

Fig. 8.5 See that?

achieve success. This would be the eighth day of his project. We chat briefly about the motor and make plans for his write-up of his project. Surprisingly, Matthew is not through. He wants to return the following day to adjust his motor, and assemble a few examples of his electromagnets to show the class.

This would be an impressive moment in Matthew's project as he worked alone to perfect his motor. In order to work correctly, each part of the motor needed to be carefully adjusted, thus it took several versions to get each component aligned properly. He began work on the previous afternoon and worked this entire class period. He remained after the class ended because he was certain he would succeed. His success was a testament to his perseverance and confidence in his abilities.

Day Eight: June 6, 2003

On this day, Matthew prepares to show his accomplishments to his classmates. He has created a workspace at one of our side tables. He has assembled several ammeters and voltmeters, a VARIAC (his variable power source), many spools of wire, tools, several electromagnets, and his motor. He will assemble his artifacts and explain each one to anyone who visits his workstation. It is interesting to note that he is wearing a white lab coat as he works. As the class starts, he takes a large coil of wire and connects it to the VARIAC. Sean approaches to see what he is doing. Matthew explains:

12:04:21	Matthew	Pointing to the wire coil as he wiggles his fingers to simulate current going through the wire	When you pass a current through a coil of wire you make a magnet

Matthew then retrieves a small metal rod, which he hands to Sean

12:12:09	Matthew	Handing Sean a small metal rod	Come here hold this
12:14:09		Sean hesitates: Matthew encourages him to place the rod in the coil of wire	It's OK; it ain't going to shock you.

As Sean places the coil in the wire, Matthew reaches over to the VARIAC and adjusts the voltage. As he does so, he looks intently at Sean.

12:04:21	Matthew	Looking intently at Sean	Let me know if you feel something

As Sean lowers the rod in and out of the coil of wire, Matthew adjusts the voltage on the VARIAC (Fig. 8.6).

Matthew: Do you feel it?

Sean nods a silent yes.

Matthew explains that the current in the coil makes a magnet that attracts the metal. Sean leaves the table and Matthew continues to prepare his artifacts. He connects the wires of one of his electromagnets to the power source. It is a long

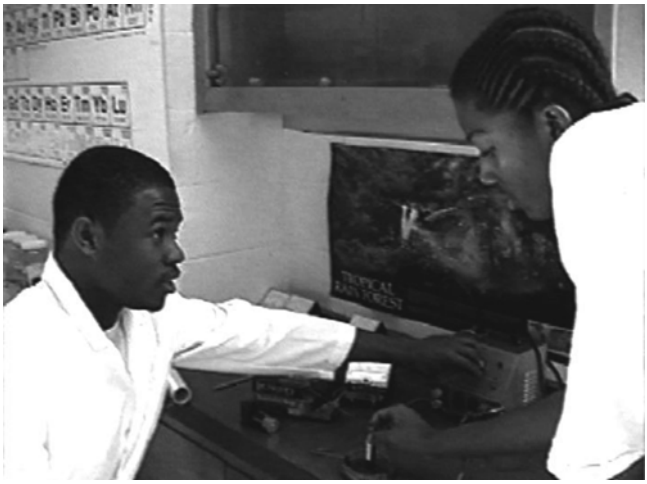

Fig. 8.6 Do you feel it?

piece of PVC pipe with many turns of orange wire encircling it. There is however insufficient power to run it: to run it efficiently he needs the power supplies in Mr. Price's shop. He then connects a smaller electromagnet to the power source. It has a small metal rod as its base He draws a piece of metal to it to test its magnetism. As he does so, Ian asks a clarifying question.

Ian: So where's it magnetic? (Figs. 8.7 and 8.8)

08:45:12	Ian		So where's it magnetic? Only at the front? At the two ends?
08:50:22	Matthew	As he touches metal to the two ends	Only at the ends.
09:12:28	Matthew adjusts the power on the VARIAC, tests the magnetic field. It is not strong enough. He resets the VARIAC, readjusts the voltage: the magnet works. He turns and nods to Ian.		
09:13:29		Nodding to Ian	Yeah it works, it's attracting
	Matthew continues to adjust the power to test the ends of the magnet. As he does so Ian asks		
09:27:20	Ian	As Matthew tests the magnet	And where's the magnetic field coming from?
09:29:19	Matthew	Responding without hesitation. Circling his fingers to simulate the turns of the wire	The magnetic field is coming from the wire
09:32:11	Ian	Probing	But…Why?
09:34:16	Matthew	Circling his hands to simulate the current going through the wire	There's current… current going through the wire
09:38:07		Testing the magnet's ends	I'm not really sure which end is north or south
09:40:23	Ian		Well that's OK. But current is causing the magnetic field?

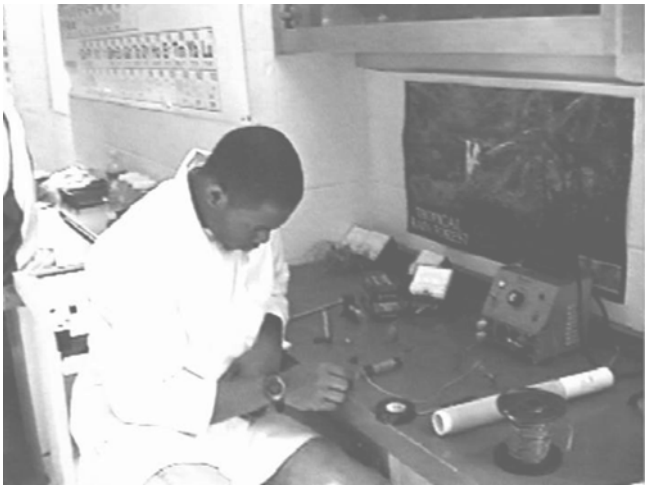

Fig. 8.7 Testing the electromagnet

Fig. 8.8 Matthew assembles an electromagnet

09: 46:10	Matthew	Nodding in agreement. Circling his hands	Yes. It's going through the coils
09:50:08		And then remembering	The more amount of coils you have, I think, the… the stronger the magnet

Matthew has gained an excellent understanding of the relationship between current flow and magnetic fields. He is aware that the field is strongest at the ends, and that the greater the number of coils, the stronger the field. This canonical knowl-

edge was gained as a result of his own experimentation, reading, and interactions with his teacher. It is now part of his cultural capital. After answering Ian's questions, he pauses for a few moments to consider his next action. He decides to build another electromagnet as the first magnet has a very weak field. To assemble his electromagnet he cuts a length of wire from a spool, deftly strips the ends, and selects a small copper rod to serve as the base of the magnet. He tapes an end of the wire to the rod then expertly wraps the remaining wire around the rod until the entire dowel is covered by wire. He then connects the wires to the VARIAC to test his magnet. A curious event occurs, as the magnet does not work. All of his magnets have worked efficiently but this one has no magnetic field. Matthew is puzzled as he has been so successful to this point. His next moves evidence his strong identity as science student and his expert knowledge of his equipment. He disconnects the magnet from the power source and sets an ammeter across the circuit, to check the current. Ian watches patiently as Matthew works. He then poses a question:

13:38:21	Ian	Questioning	So if it wasn't working, what are you gonna do?
13:40:18	Matthew	Speaking as he connects the ammeter to the circuit	I'm gonna see it there's any current going through this wire

Matthew suspects the power source is at fault. He has noted at various times that the power source in our lab is not as dependable as those in Mr. Price's shop. The meter confirms that there is little current going through the circuit. Matthew resets the VARIAC: still no current. He tries again with the same results. He stops to consider his options. Ian proposes a solution (Fig. 8.9):

Ian: Do we have batteries here?

Matthew nods in agreement and sets out to find a battery. He returns with a 6-volt dry cell. Before using the battery, he checks its power with a voltmeter, as many are

Fig. 8.9 Considering his options

Fig. 8.10 Tania, Ian, and Matthew view the new motor

weak from constant use. The cell is fine, so he sets it into the circuit. He includes the ammeter to check the current flow. He checks the magnet. It produces a very weak field in the wire, but it is not as strong as he expected. He replaces the magnet with his earlier one, (the one with an iron rod as the base), and it produces a stronger field. He compares the two magnets: one has iron as a base, the other copper. He does not fully understand why the field is so weak. He is not frustrated by this situation: he will investigate why the copper base magnet works so differently from his other magnets. He has sufficient knowledge and confidence to continue the exploration on his own, as he does not have time this day. Matthew lays out his various electromagnets for display. Once he decides that he has assembled at least two working magnets he turns to the motor. He takes the cardboard housing in his hands. The cardboard is weakened in many areas as he has worked with it for various days. He looks around the room. He notes to himself, "I gotta fix this." Ian and Matthew look about the room for resources to use for a new motor housing. Nearby, a group of students are using the K-Nex set to build a roller coaster. Matthew realizes the pieces will serve well. He takes a few pieces and assembles a new sturdier housing for his motor. He dissembles the motor from the previous day's work and reassembles it on its new housing. After a few brief moments, he sets the new motor to work. It runs efficiently from the very first attempt. Tania, a fellow student is nearby (Fig. 8.10).

Matthew explains each one of his electromagnets to her: the coil, the PVC pipe, as well as the copper magnet (which he notes does not work). He shows her each part of the motor and explains how the current creates a magnetic field in the coil, and how together with the surrounding magnets causes the armature to spin.

As Tania leaves, other students stop by the bench to observe Matthew's magnets. Though each of his artifacts represents complex scientific phenomena, Matthew is

able to explain how each one works with impressive simplicity. As each of his fellows students approach Matthew demonstrates his magnets. At one point, Matthew sums up his emotions to a fellow student. Holding the coil of the motor in his hands, he smiles broadly and remarks, "I'm happy, I'm happy."

Matthews's work with his electromagnets demonstrates an exemplary level of scientific fluency, but more importantly, his attitude and work methods indicate a strong feeling of membership in the culture of the school science community. His attire is most interesting as lab coats were used only during our regular lab periods, and even then, few students wore them. A few other science teachers and I were the only ones who regularly used them. On this day, Matthew is the only student wearing a lab coat, however he wears it comfortably as it is now part of his identity. His knowledge of the science of electromagnets is impressive, as he has learned the content from a variety of teachers in a several different fields. When asked a question he does not know, he stops to consider the answer, and when unsure he will easily say, "I don't know, I'll have to figure that out." His approach to the non-working magnet, illustrated his understanding of the various parts of the circuit, and how to use his equipment to deduce the problem with the magnet. Once he realized that he did not have the proper materials or knowledge, he made the decision to first acquire the requisite resources then return to the problem. This was a most impressive decision. This perseverance was evident in his successful motor project as that too was initially a failure. However, in that instance he had the requisite resources and cultural capital to resolve the issue. All he needed was the time to make the needed modifications. His commitment speaks to his strong internal confidence in his abilities as student. It is a belief that is well founded as his many successes have only increased his sense of possibility as a science student. These are all evidence of a successful science identity and a strong solidarity with the culture of the school science community (Fig. 8.11).

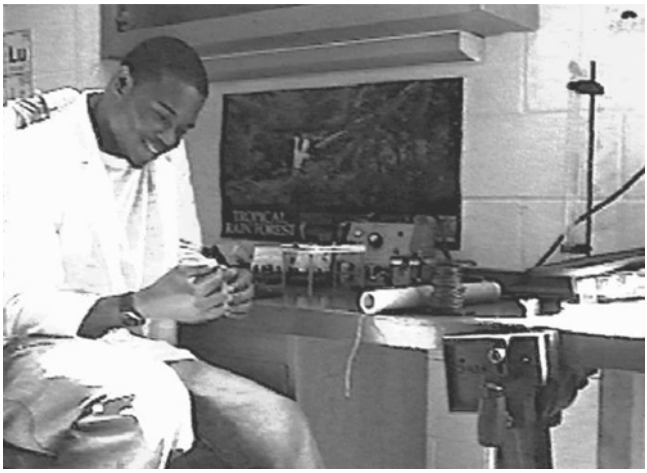

Fig. 8.11 "I'm happy, I'm so happy"

In many ways, Matthew's project represents a culmination of our many understandings of the structural components of transformative learning environments. Central to these environments is our respect for and efforts to honor the differing cultural perspectives that populate the classroom field. The difficult work of teaching in urban schools begins with our awareness of the cultural differences that exist between urban youth, the school (as social institution) and we their teachers. Such an awareness allows us to effectively communicate and negotiate across difference in ways that engender the trust and mutual respect that are essential to learning environments that maximize student potential.

It is instructive to note the interactions between Ian and Matthew. Although they are from radically different life histories, their interactions are consistently cordial, supportive, and collegial. During their two week project there is not one instance of resistant, oppositional culture, symbolic violence, or activity that might disrespect or disprivilege either Matthew or Ian. It is finally the deepening trust; respect and increasingly positive emotional energy that together form the foundation to Matthew's successful motor project. These interstitial cultural resources helped him develop the solidarity with the culture of the science classroom and identity of a successful science student. The image of him at his workstation, wearing his lab coat and broadly smiling is evidence of his very positive emotional state and identity as a successful science student.

The availability of a wide range of human and material resources is the second important component of the successful project. As noted earlier, the budgetary constraints faced by urban schools limit educational opportunity because rigorous challenging learning environments require resources that many schools lack. During his project, Matthew had access to a wide array of human and material resources that together enabled him to understand and build his various electromagnetic artifacts.

The Need for Continued Research

The stories presented in this chapter, provide evidence of the centrality of identity as an analytical tool (Gee 2000), in our efforts to provide transformative educational opportunity to students from traditionally marginalized populations (Tan and Calbrese-Barton 2008). Although these stories highlight differing aspects of identity formation, each underscores the critical role sociocultural perspectives play in our ability to create learning environments that provide students the resources they need to maximize their learning potential (Tobin et al. 2005).

In Ya-Meer's case our work was informed by our understanding of how cultural differences can occasion moments of symbolic violence (Bourdieu 1991), that cause students to enact oppositional resistant culture. Cogenerative dialogues were developed as a resource to help teachers and students articulate and resolve hidden contradictions that constrained agency within the classroom field. Although there was an initial confrontation, Ya-Meer chose to access these resources and disavow further confrontational culture. His actions evidence his affiliation with the culture

of the school science community, because as Faircloth (2012) notes identity is a "set of choices and practices co constructed between an individual and a specific community" (p. 187). Thus, the dialogues provided the structural resources that helped him continue to develop his successful school identity. Once the contradictions were resolved, Ya-Meer became one of our community's highest achieving students. He graduated successfully and matriculated at a nearby college.

In Matthew's case, our work was informed by our research on the sociology of emotions (Turner 2002) and the role that positive emotional energy has upon the creation of identity (Collins 2004). In his story we see how a series of successful social interactions helped him move from a role as a peripheral learner to one of "master practitioner" (Lave and Wenger 1991). It was the increasing positive emotional energy engendered during his social interactions that facilitated his highly successful school science identity (Olitsky 2007). The image of him at his workbench wearing his lab coat, surrounded by his various electromagnets, and tools is suggestive of a student with a strong emotional affiliation with the school science community. His broad smile and emotional statement, "I'm happy, I'm so happy" are indicative of the highly positive emotional energy engendered during his project. As a result of his newly formed identity, Matthew was able to alter his history of academic underachievement and graduate from our school. Though he did not continue his studies upon leaving our school, he eventually enrolled in a local two-year electronics institute.

Ya-Meer's and Matthew's stories evidence the exemplary learning that occurs when sociocultural perspectives are used to inform teaching | learning in the urban setting. The stories of these students (and others in our research literature e.g., Carambo 2009) suggest continuing attention to the social-cultural theories as part of our effort to provide equitable educational opportunity to students from traditionally marginalized populations.

Given the ongoing expansion of immigration and changing demography of our society, social and cultural diversity will continue to increase in our nation's cities and within our urban classrooms. As teachers (and administrators) face new cultures within our schools, methodologies that help us communicate | negotiate across difference and thereby create the structures that enable the creation of successful school identities is needed (Flum and Kaplan 2012).

If our goal is to provide equitable educational opportunity to diverse student populations then we, as members of the research community must employ theoretical perspectives that provide the philosophical and pedagogical resources needed to address increasing diversity in ways that provide a transformative education to all children.

As documented in this chapter, sociocultural perspectives provide frameworks with which we can create environments that help urban youth maximize their learning potential and become exemplary, confident learners. Once done, instances of resistant, oppositional culture and disengagement lessen, as students are able to forge identities that allow them to deploy their stores of social, cultural and symbolic capital. In these instances, the "achievement gap" between dominant and non-dominant cultures will lessen and in many instances disappear completely.

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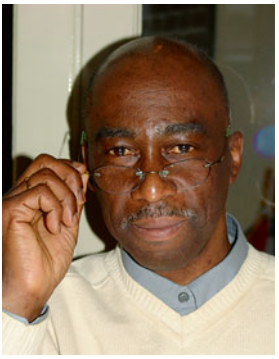

Cristobal Carambo was born in Havana Cuba. His family immigrated to the United States in 1959 and settled in Boston, Massachusetts where he lived until he moved to NYC to pursue a career in the theatre. As actor-dancer, he performed a wide range of plays and musicals in the United States, and abroad. In addition to his work as performer, Cristobal taught theatre at Bard College, City University of New York, and as artist in residence throughout the NYC public school system. In 1987 he married and decided to leave the theatre and earn a degree in science education. Carambo and his family moved to Miami Florida where he completed his Bachelor of Chemistry Education at Florida International University. He met Dr. Tobin in 1997 and enrolled at Florida State University where he earned a Master of Science Education degree. During this time he engaged in his first collaborative research in science education and made his first presentation at the 1998 NARST conference in San Diego. Carambo moved to Philadelphia in 1999 to continue his studies and research efforts. He taught science at University City High and joined Dr. Tobin's DUS research group. As teacher | researcher, he co authored many articles and presented at local and national science conferences. In 2001, he enrolled in the Master of Chemistry Education program at the University of Pennsylvania. Upon graduation, he decided to continue his research efforts in sociocultural theory and urban science education at Curtin University. In 2006, he left the school district to complete his dissertation. During this time he worked as adjunct faculty at the University of Pennsylvania, Queens College, and Drexel University. He was awarded his doctoral degree in 2011. Dr. Carambo currently teaches chemistry at the Philadelphia High School for Girls.

Chapter 9
Science and English Language Learners: Creating Opportunities to Align Teaching and Learning with Students' Needs

Gillian U. Bayne and Romil Devang Amin

The Challenge

In 2010, The American Community Survey reported there to be a record number of 40 million immigrants in the United States.[1] This number has not only directly challenged the work force, but has forced those in education to confront many issues, including those related to language differences, pedagogy, practice and policy that are specific to the needs of the immigrant community. While many large cities continue to be traditional gateways for the influx of immigrants, including those whose native language is not English, recent trends point to an increase in the movement of newly arrived foreign-born people to non-traditional destination states. No matter where their final destination, it is common knowledge that newly arrived foreign-born students, whose native language is one other than English, often struggle to succeed in their new living and learning environments (U.S. Census Bureau (2001a, b). The National Center for Education Statistics reports that in 2010 7an estimated 4.7 million public school students (10 % of the total number of public school students) were ELLs (NCES 2011). The science classroom has proven to be especially challenging for students who are English language learners (ELLs), teachers, and parents as they try to navigate bureaucratic layers of the educational system in order to access and appropriate human and material resources necessary for teaching and learning science.

[1] http://www.census.gov/population/foreign/

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In the past, it was common practice to house non-native English speaking children in classrooms that were specifically designated for *English as a Second Language* students. Recently, policies that place ELLs into general education classrooms with students who are proficient in English have been put into effect. While there are many benefits to having a heterogeneous learning environment, new challenges surface. For example, the number of students in urban science classrooms is often over 30, creating an atmosphere that can be very frustrating for both teachers and students. In addition to teaching challenging content, the English language must be emphasized in science curricula. Nazan Bautista and Martha Castañeda (2011) report this to be especially difficult for ELLs at the secondary level, "because these students have limited time to develop their language skills while attending to academic content" (p. 35). While the new Common Core State Standards are being heralded as key factors in moving toward improving the state of affairs generally in education, "little specific acknowledgment of the challenges [that exist] for ELLs" is made in them (Coleman and Goldenberg 2012, p. 46). Factored into the challenge of teaching to the specific needs of ELLs in science classrooms are the requirements for evidence of student competence in content knowledge, understanding, and application.

Reform emphasizing high academic standards and equity for all students has been under way for more than two decades (American Association for the Advancement of Science [AAAS] 1989). The *National Science Education Standards* (National Research Council [NRC] 1996) state that "scientific inquiry is at the heart of science and science learning" (p. 15) and "inquiry into authentic questions generated from student experiences is the central strategy for teaching science" (p. 31). Although the *Next Generation of Science Standards* (National Research Council 2011) invites the science education community to more carefully examine the nature of teaching and learning science, questions that need to be answered remain – especially as they relate to the changing demographics of our student population. How, for example, do we properly assess the application and outcomes of these standards given the varied customs and values that exist within culturally and linguistically diverse science classrooms. How do we appropriately address science teaching and learning practices when the student population is not composed solely of English language speakers?

In this chapter we provide an opportunity to explore how a group of ninth grade ELL immigrant science students, who together with their ELL schoolmates make up over 94 % of the student population in a small public international high school in the Bronx, New York navigate the complexities of new educational and social cultures. We, a science education faculty member, Gillian, and former science education graduate student, Romil, worked together over the course of 1 year to try to understand the experiences had by the ELLs in their science class. Critical ethnography and cogenerative dialogues (cogens) were employed in a coordinated fashion as a means to study challenges related to (a) the acquisition and utilization of the English language in the science classroom, (b) the teaching and learning of science as a cultural process, (c) cultural alignment and misalignment between teachers and students, and amongst students themselves, and (d) the involvement of

teachers, students and other stakeholders in improving science experiences for ELL immigrant students. Throughout our research, the following overarching question helped to frame the research presented in this chapter: To what extent does the use of cogens produce success in science classrooms with large numbers of ELL students?

During the course of this chapter we first offer an overview of considerations to take when assigning and aligning responsibilities for teaching science to ELLs. We review some of what the literature reports on being necessary for effective planning and execution of instructional strategies, and highlight the importance of examining teacher perceptions and beliefs as they relate to teaching ELLs. Second, we discuss the value of acknowledging difference in the cultural views of ELLs, as well as learning about their communities of origin – both of which can help to inform the understanding of how individually and collectively student schemas and practices get enacted in the science classroom. Next, we present our theoretical framework, upon which the foundation of our research using cogens with ELLs is based. We present two short vignettes taken from whole class cogens that highlight (a) students trying to make sense of how and why respect within the classroom gets discussed, practiced and (re)enforced, and (b) students grappling with trying to understand and make meaning of science content, while being aware of the need to perform well on high-stakes end of the year science exams. Finally, we discuss how our work can help to inform the field of science education, and why an expansion of this work could be an important mediator in examining and appropriately addressing the needs of our increasingly linguistically and culturally diverse population of science students.

Considerations: Shared Responsibility and the Need to Know

Teaching ELLs must be considered a shared responsibility between the science teacher, other teachers and many of the professionals that interact both directly and indirectly with students. While the need persists, most science teachers do not receive formal training in teaching linguistically and culturally diverse students. It is incumbent upon science teachers to take initiative in seeking out knowledge and resources that will help to find appropriate ways to teach ELLs in a nurturing and supportive learning environment.

Instructional congruence, a notion referred to by Okhee Lee and Sandra Fradd (1998), has been used to identify and describe the process of, "mediating the nature of academic content with students' language and cultural experiences to make such content (e.g., science) accessible, meaningful and relevant for diverse students" (p. 12). In order to establish instructional congruence, teachers need to know several important things about their students. First, teachers need to know who the English language learner students are in their classes and how these students have been acquiring literacy and English-language proficiency over time. Teachers are also encouraged to reflect upon what kinds of language and cultural experiences students

bring to the learning environment that encompass their understandings of the Nature of Science. Sandra Harding (1998) encourages us to be open to the notion that science can and does take on varied forms of understanding and practice in varied cultures. It is imperative, therefore, that teachers be sensitive to the potentially damaging effects of having students' indigenous and/or non-Western ways of knowing science come under attack. We are reminded that, ethnic practices enacted in "a student's immediate environment plays a very significant role in learning, determining how concepts are learned and how they are stored in the long term memory as schemata" (Jegede 1999, p. 119). Respecting and activating students' prior knowledge and understandings are needed in order to foster engagement. Relating what is being learned to aspects of students' lived experiences will help students to develop a deeper understanding of science. Being mindful of perceptions is equally important when working with students who are linguistically and culturally different, for "while teacher perceptions may distort their actual teaching practices, their perceptions still need to be taken into account when designing interventions, as teachers are more likely to enact changes when those changes reflect their beliefs" (Lee et al. 2009, p. 264). These are not easy things for teachers to come to know, grapple with or enact – they require patience, keen observation and attention to details, refraining from judgment, a sincere desire to help all science students, and the determination to continue a strong reflective practice.

Traditions and Values Mediate Learning

It is necessary to recognize, for example, that familial traditions and ethnic views also affect student performance in the classroom, especially if the student is a recent immigrant. Children's engagement with scientific information is mediated by their prior linguistic and cultural knowledge (Luykx et al. 2007). The classroom can be considered a potluck dinner where each child brings his or her own learning processes and his or her own method of interpreting the natural and social world. A child's upbringing, the immediate environment, and his or her parental views about education can heavily influence learning. Personal experiences strongly affect students' decision-making abilities and worldviews. Most often school systems are organized and aligned with the upbringing of "mainstream" children (i.e., White, middle-class, native English speakers). The school environment generally meets the expectations of the family values of these children, and reinforces what they are taught at home. Nevertheless, it must be strongly emphasized that children who are not "mainstream" also bring important resources from their home environments, from both an epistemological and phenomenological perspective, that can serve the individual and collective as intellectual resources for science teaching and learning (Lee 2002).

It is crucial, therefore, for teachers to consider these cultural differences and build upon prior student knowledge in order to establish an intellectual library of resources within the classroom. It is plausible, however, that certain linguistic or

cultural traditions may be perceived by those in the "mainstream" as being a disservice to immigrant non-native English speaking students' educational experience, and as a result, the way that science is taught in some schools may be experienced by some as a form of symbolic violence. While such inconsistencies may create difficulties for students' learning of science and for the teachers trying to teach science (Aikenhead and Jegede 1999), they provide all the more reason to continually strive toward creating opportunities whereby teaching and learning science can become more equitable and resourceful for all.

Discovering ELL Students' Communities of Origin

Katherine Bruna and her colleagues provide an example of a firsthand account of what ELL students' lifestyles were like in Pueblo (pseudonym), Mexico, prior to immigrating to Gardston, Iowa (Bruna et al. 2007). This exemplar underscores the need for a clearer understanding of ELL students' habitus, schemas and practices, and how they get enacted in the classroom – both within students' homelands and their new classrooms in the United States. Along with her colleagues, Bruna discusses how the classroom experience is related to the students' former lives, hoping to provide valuable tools for science teachers to use to transcend and transform challenges. Being able to understand poverty and the central role it plays in a community context is of great importance. Oftentimes, it is because of larger sociohistorical forces, that formal education traditionally has *had* to take a back seat to the immediate concerns of survival – a recurring theme in the experiences of many ELL students. As such, education becomes an investment in the future, instead of a situation where children might have formerly been traditionally bound by household chores and duties in order to help economically rather than attending school. Science teachers play an important role in nurturing the interests of such students, in that they have potentially many resources (i.e., inquiry and project based learning activities) from which with they can draw upon to capture the interests of their students. Moreover, they can use this relationship to build connections between students' lives and the curriculum.

Linguistics and Emotions

In order to address the issue of equitable education, researchers sought how to address linguistic and cultural influences. Solano-Flores and Nelson-Barber (2001) assert that the ways students make sense of science test items are influenced by the values, beliefs, experiences, communication patterns, teaching and learning styles, and epistemologies originating from their cultural backgrounds and the socioeconomic conditions in which they live. This finding only complicates the picture when the students find themselves at the crossroads of two different cultures, many times, with many clashing beliefs.

Language plays a very important role in establishing and maintaining beliefs and in enacting patterned actions, since it is the primary mode of communication within groups. Moreover, it is also an excellent way to invoke and express emotions. A classroom is an ideal setting for students to express themselves in front of their peers. Since ELL classrooms are comprised of students from many different ethnic groups, one can imagine how communication would tend to occur in different languages depending upon the student groups.

Many researchers agree that emotions can be greatly influenced by one's ethnic affiliations. This means that members of particular groups identify different emotions differently based upon social and cultural settings. This view is well captured by Rosaldo (1984), who suggests that emotions are "self-concerning, partly physical responses that are at the same time aspects of a moral and ideological attitude; emotions are feelings and cognitive constructions, linking person, action, and sociological milieu" (p. 304). Such findings shed light upon the importance of emotions in the classroom and correctly translating them in order to enhance student learning. By paying close attention to the role that emotions play in a classroom, researchers can examine the links between language, emotions, and cognition. Recent studies that measure the changing emotional climate of science classrooms evidence correlations between changes in teacher practices and student achievement (Ritchie et al. 2013).

English Language Learner Schools

In order to meet the ever-increasing needs of the immigrant population, the New York City Department of Education, along with support from local community colleges and subsequently the Bill and Melinda Gates Foundation, established English Language Learner Schools in 1985, currently referred to as *Internationals Network for Public Schools*. These schools seek to serve English Language Learners that have immigrated within the last 4 years. In an effort to address the growing population of recent immigrant with limited or no English language proficiency, these schools strive to provide quality education for recently arrived immigrant students by developing and networking small, public high schools based on the Internationals Approach, a unique educational model through which students explore interdisciplinary academic content in learner-centered environments with linguistic heterogeneity (http://internationalsnps.org).

Internationals students are encouraged to learn collaboratively in small groups with students who do not share the same ethnic background or language so as to build on individual and collective strengths. Some students have had little or no formal education while others have had interrupted education, having gone through significant periods without any formal schooling. Due to the nature of the student population, it is crucial that the teachers rely on as many cross-content, hands-on activities as possible, supplemented by vivid animations and visualizations. A goal of having students work with others on academic projects is to foster active student use of and growth in language. This pedagogical approach, called the *Internationals*

Approach, is based upon five major tenets (1) heterogeneity and collaboration, (2) experiential learning, (3) language and content integration, (4) localized autonomy and responsibility and (5) one learning model for all (International Network for Public Schools 2012/index/html). The approach professes to be holistic in regard to student education. Schools within the Network form close-knit, supportive communities for students who may feel displaced after moving from another country and are unfamiliar with American language and culture. Differences among students are the norm and, as such, students are encouraged to celebrate their cultural and linguistic individuality.

Foundations of Theoretical Underpinnings

In this research, the dynamic interactions of cultural, social and symbolic capital are examined inside of ELL science classrooms through theoretical lenses primarily grounded in those that are sociocultural in nature. Capital, as defined by Pierre Bourdieu (1986) is an, "accumulated labor which when appropriated on a private, i.e., exclusive basis by agents or groups of agents, enables them to appropriate social energy in the form of reified or living labor" (p. 241). In our work, social life in the science classroom is explored through a careful examination of the dialectical relationship between agency and structure, where each presupposes the other, both being operationalized together. We also dialectically conceptualize culture as being the dynamic interaction between schema and practices – whereby a system of symbols and its associated meanings and practices (Sewell 1999), get enacted in a variety of what we refer to as fields. We consider fields to be places and/or sites that have both temporal and spatial dimensions. Culture, as described above, mediates actions by shaping this collection of symbols, stories, rituals and worldviews. Fields have resources (i.e., material, human and temporal) that promote structure; agency within a field involves being able to access and appropriate these resources. Science classrooms are dynamic fields, and become sites where culture gets enacted as well. Because culture is experienced both individually and collectively, it readily gets enacted, irrespective oftentimes of the physical space. It is because of its fluid nature that we see culture as being enacted in all fields, and we view fields, therefore, as existing without boundaries. Their natures allow for culture that is enacted in one field to also be enacted, translated or repeated and/or transformed in others. Social life within a field (i.e., teaching and learning in an urban ELL science classroom) is mediated by agency and structure (Tobin and Roth 2006).

Cogenerative dialogues (cogens) are dialogues that are had about shared experiences that involve teaching and learning (Roth et al. 2002). Participants that are involved in cogens are commonly students, instructors, researchers, and sometimes administrators. Cogens have a long history of being used as a powerful tool in urban science classrooms to help catalyze change, both at the individual and collective levels. They help, for example, to understand and improve upon the ways that science teachers and their students interact; help meet the science teaching and learning needs of students and teachers in a mutually agreeable and respectful way;

improve the delivery and utilization of science content material; create new opportunities for students who had typically been involved in science marginally, to be involved in the science learning environment centrally (Bayne 2009). As is the case with science classrooms, cogens are dynamic social fields – they provide for the physical, emotional, social and intellectual space needed for addressing challenges and for each participant to share in the responsibility of seeing that agreed to measures are enacted. They create opportunities for a community to share opinions, offer solutions, work collectively to meet desired goals of the group, create solidarity, and to learn and develop in ways that improve the teaching and learning of science. Face-to-face interactions (Turner 2002) are valued highly in cogens and participants welcome possibilities that give rise to mutual understandings and generate positive emotions (Collins 2004). Cogens afford the creation and enactment of a newly transformed, or *hybridized* culture. This hybridized culture is one that allows participants to experience polysemia, shared understanding, and polyphonia – opportunities necessary for transforming the learning environment into one that in this research supports the needs of ELL students and their teachers. The varied ethnicities, cultures and languages, along with urban youth culture, that are brought to teaching and learning science in diverse urban settings, are extremely valuable resources, which can if understood well, afford the learning of mainstream discourse, including science (Bayne 2012). Consequently, cogens encourage successful interactions across sociocultural differences, including those related to race, ethnicity, cultural values, language differences, gender, age and epistemologies – a key consideration for the effective teaching and learning of science with immigrant ELL students. The number of participants that get involved in cogens varies. Cogens typically have 6–8 participants, although there have been studies whereby one-on-one cogens have been enacted as well as cogens with up to 16 participants, and, as is the case in this research, whole class cogens have been enacted.

Preparing ELLs in High School Science and Beyond

The research presented in this chapter is situated at The International School (IS),[2] a small public high school located in The Bronx, New York City. The third cohort of students admitted to IS in 2007 was composed of 49 % female and 51 % male. Over 94 % of students were recent immigrants (or the children of immigrants) – hailing from The Philippines, Yemen, the Dominican Republic, Bangladesh, Mexico, Albania, Ecuador, Guatemala, Guinea, and the Democratic Republic of Congo. The Department of Education lists the ethnicity of the students as less than 1 % American Indian or Alaska Native, 10 % Black or African American, 82 % Hispanic or Latino, 5 % Asian or Native Hawaiian/Other Pacific Islander, and 2 % White.

IS's mission focuses on serving recent immigrant English language learners and preparing them with the linguistic, academic and cultural skills needed for success in college and beyond. All students in a ninth grade Living Environment class were

[2] Pseudonym.

invited to participate as student researchers in a variety of qualitative research activities over the course of 1 year as a means to understand challenges both inside and outside of the science classroom. Data presented in this chapter were collected during the 2009–2010 academic year. We have chosen to present and discuss two different short vignettes that are typical of some of the discussions had around improving science teaching and learning, as well as concerns related to language, respect, and how to properly prepare for the end-of-the year New York State Living Environment Regents Exam.

Involving Students in the Research

All students (now referred to as student researchers) in one of Romil's ninth grade biology classes were invited to participate in cogens regularly during the school term. While many attempts were made to begin cogen discussions with a small group of students, we were constantly challenged with doing so regularly because of challenges with the academic scheduling. We decided that we would conduct cogens during the last part of Romil's class one day a week. We found that while this was a large amount of time devoted to cogens, that both students, Romil and school administrators believed that the benefits highly outweighed the effects of not using that time as one would traditionally. Using cogens as a means of improving the teaching and learning of science with ELLs was of great interest to both of us because of the very complex issues that Romil had to deal with while teaching secondary science. Romil was introduced to cogens during his immersion into the New York City Department of Education Teaching Fellows Program during the summer of 2007. As a new teacher who was very familiar with the challenges faced by immigrant students whose native language is not English, Romil readily saw the value in using cogens with this population of students. Student researchers were very participatory in all aspects of the research and played pivotal roles in (a) videotaping classroom lessons, activities, and laboratory experiences (b) selecting specific vignettes for whole class and small group discussions, both at the *meso* (the normal levels/speeds at which life unfolds) and *micro* levels (levels/speeds that are evaluated when videotape viewing and analysis are slowed down) and (c) participating in, and sometimes leading discussions involving the nature of the unfolding of events in specific vignettes. Cogens included these student researchers (and most times the entire class) as well as Romil, and a university researcher, Gillian. The evaluation of tape selections in the cogens and in other small group research meetings often served as the foundation from which classroom transformation became possible. Feedback regarding individual and/or collective practices, mutual focus, entrainment, solidarity and positive emotional energy became salient factors by which the nature of the varying learning environments (i.e., the classroom and laboratory) functioned. Data from the research were used to help inform student learning and improve teacher practice. Interviews and cogens that detailed data around specific formal and informal assessments, student project work and student oral presentations, became critical components to obtaining more accurate

perspectives from the diverse student population of the Living Environment class. Finally, the authenticity of this research was evaluated using Guba and Lincoln's (1989) criteria: ontological, educative, catalytic and tactical authenticity.

Multiple sources of data were collected during this year-long study. Video data were collected regularly during the study. Approximately 4 h of footage was taped per week, which included a once a week opportunity for participation in cogens. Weekly lesson plans, journal entries, student made artifacts, field notes and survey artifacts served as additional data resources. Interviews were transcribed and video was reviewed, generating short clips or vignettes. Student researchers participated in many aspects of the data analysis, providing insider perspectives on the data constructions and interpretation. All relevant videotapings were digitized and analyzed using iMovie HD and the professional version of QuickTime Player (Macintosh OS X). This software allows recordings be slowed down or accelerated, affording researchers to interpret findings image by image and to capture phenomena at the microlevel.

In the next section, we present the two short excerpts from vignettes that aim to provide examples of how cogens can help to illuminate matters that need to be addressed with ELLs, and how collectively the responsibility for finding solutions to these matters may be untaken. We use transcription conventions employed by Roth and Hsu (2010) as detailed below in presenting the vignettes.

[	beginning of overlapping talk or gesture;
=	equal sign at the beginning of turn indicates no gap between two speakers;
(2.3)	elapsed time in tenths of a second;
::	colons indicate lengthening of the preceding phoneme, approximately one tenth of a second;
–	a dash indicates sudden stop in talk;
°oh no°	utterances surrounded by degree signs are less loud than the surrounding talk;
(())	double parentheses (italicized) are used to enclose comments and descriptions.

Vignette Excerpt #1: Why Minus Points?

Romil, referred to by his students as Amin, encouraged conversations to take place about concerns that students had related to (a) the way that the science class was functioning and/or (b) whether or not they had recommendations for improving it. During the cogen vignette highlighted below, two student researchers videotaped, while two others, Julio and Roberto were positioned at the front of the classroom, taking notes on the whiteboard of what was being said, while the rest of the class (including Romil and Gillian) was seated informally around the large rectangular blacktop tables that took up a majority of the classroom. The vignette below begins with Julio posing the following question and comment to Romil:

Episode 1

01	Julio:	Em, Amin. Why do you subtract points from our work in class? It's not fair that you do this.
02	Others:	=Yeah ((other verbal and physical indications are made by students acknowledging their agreement of Julio's point)).
03	Roberto:	[Yeah, it's not fair. Why do you do that? Is bad and it's for no reason. It's for no reason …
04	Gillian:	[Wait, wait…one at a time, please…Remember our rules that we put into place when we began cogens. Wait, someone is raising her hand over here. Go ahead. What is it that you want to say?
05	Lora:	=°When Amin°, when he wants us to be good, eh…°one minute° ((Lora taps Samaya, a student next to Lora, who has been listening to the conversation with her head down, resting on the table. There is no response from Samaya))
06	All:	((Spontaneous laughing erupts))
07	Lora:	[Stop laughing! ((Lora looks towards classmates sternly and then to Amin))
		=Can I pass it to Amin and then he can tell you? ((Looking now towards Gillian and then to Amin))
08	Gillian:	[Say that again
09	Amin:	=She wants me to translate.
10	Lora:	((Begins to speak in Hindi, which is then interspersed with some English))
		=…then nobody respect you…then he put the minus…
07	Amin:	=She is saying that when I ask people to respect me, if they don't do it, then I put minus points…
08	Lora:	=It's good.
09	Amin:	=and she's saying that's the reason °*why* I do° it – when people don't follow the rules or they don't respect me
10	Milagros:	[momentito, voy a hablar…em, maybe when Amin is teaching, ¿Cómo se
		dice…en la pizarra? °Oh°…, en the board… Sometimes, Amin says, "be quiet, °please°" ((gesturing with her index finger to her mouth)) and some people, don't quiet, so that's reason for why he put °minus points° ((ending explanation with a smile)

The beginning of this episode begins with a question being posed by Julio, a taller than average ninth grade student who is able to immediately command attention from all when he speaks. Julio asks (in quite a matter-of-fact manner) why Romil takes away points that students earned on their science assignments. After the question is posed, there is an immediate 'chiming in' from other students, agreeing with

the sentiment that taking away already earned points is unfair, a point also reiterated strongly by Roberto in turn 3. In turn 4, Gillian reminds the students of the rules that were generated in an earlier cogen, which included that one student is to talk at a time when hearing students talking at once, and invites Lora to speak.

Lora's contribution to the cogen in this vignette is very significant in a number of ways. First, Lora, one of a few students whose primary language in this science class is Hindi, has been struggling with speaking English in the science class. She seems to feel increasingly interested in what is discussed in this cogen and appears to take more risks at trying to express her understandings of why Romil has been removing points from students' assignments in English to her classmates. At first, Lora attempts to get help with saying what she means to say in English from one of her classmates, which is unsuccessful. In a second attempt, she turns to her classmates (after telling them sternly to stop laughing) and quickly tries again – this time beginning in Hindi and then finishing up in English. Next, she further persists at making her point by using Gillian and then Romil as human resources to get permission to translate what exactly it is that she wants to say from Hindi into English; she is accessing and appropriating the resources that she needs to accomplish her goal. Finally, she affirms her agreement with Romil's practice when she says it turn 8, "It's good," which helps to build solidarity between herself (and perhaps other students who might feel the same way) with Romil. Milagros, whose native language is Spanish, appropriates Lora's resource in providing others with the opportunity to voice their understanding of what is being discussed in turn 10, as she reiterates the rationale of Romil's practice, while ending it with a smile – an indicator of positive emotions.

Vignette Excerpt #2: Best Practices for High Stakes Science Exams – How Are We to Prepare?

Preparing for high stakes, end of the year science exams oftentimes is a time when most students, teachers, parents and administrators experience high levels of anxiety. For ELLs, it is likely to be even more anxiety provoking. This vignette is taken from a cogen when Romil was beginning to prepare his students in many ways for the end of the year Living Environment Regents exam. He made special efforts, together on occasion with the English teacher, to strengthen students' science literacy skills. Here we capture a discussion that involves the logistics behind preparing students solely in English for high stakes exams versus adjusting the preparations to meet the linguistics needs of all students. The underlying goal of this cogen is to create a culture for teaching and learning science that is most feasible to helping all of the diverse language needs presented by students in the class so that they can accomplish their desired goals.

Episode 2

01	Amin:	What is the best way to prepare for exams that we have in our class as well as the Regents exams? (0.5) Do you think that we should create exams in different languages so that students can understand what the questions are requiring students to do and think about?
02	Raul:	(3.0) It's good for people when, for example the word, they translate it in many languages, it is easy to understand; but the definition is tough, I think we should do it in English
03	Taj:	[Yeah
04	Raul:	[For example, they put a test, and they don't know the definition in English, how are they gonna do the test? It's good, that people know what the words mean, but, I think that the meanings and the definitions – all that – it should be in English
05	Amin:	=What about, well, you guys know that when I draw the pictures, right? Do you think that helps?
06	All:	=Yeah
07	Amin:	[OK, so stuff like that…so, you see what the whole point is? You guys give me ideas, that I can start to use in the classroom…Like Marcia said, I should let people who have trouble understanding in English, that I should let them do it (the test) in Spanish. OK? And I can get helpers in the classroom to help me translate, so that I can know if it is correct or not. OK? So I need any other ideas like that to help me help you.

The field (cogen) has been structured in ways that allow for multiple voices and perspectives to be heard. Romil, in turn 1, is looking to his students for suggestions for practices to be enacted that will be helpful in the preparations for taking exams and performing well on them. Because of the language diversity that exists, Romil asks for feedback on whether or not science exams should be prepared in the native/primary languages that students speak so as to strengthen the understanding of that which is being asked of students on the exams. A long pause is had before Raul, in turn 2, offers his opinion, acknowledging that while an exam in a student's native language is probably a good idea, because he/she may be able to more readily understand what is being said, there will continue to be some challenges, especially as they relate to definitions. He concludes clearly that they should be taken in English. Teachers, especially those who speak and/or understand different languages, are confronted with similar challenges daily – to incorporate (or not) languages other than English into instruction. Some feel that it is imperative to do so, giving teachers another mode of entry into capturing and sustaining students' interest in and understanding of the content. Whether in the student's native language, or in other forms of communication, we ought not to forget the importance of activating students' prior

(science) knowledge as a form of engagement. In so doing, students who may not have been participating previously, perhaps largely due to language barriers, might be more willing to participate in science, ultimately strengthening their exposures in and understanding of the content.

Raul, in turn 4, offers a rationale for his opinion on how to prepare for the exam, saying that if students are prepared in many languages (reading and writing the content), they will not be at an advantage, but, will be unable to do well on exams since they are written in English. In turns 5 and 7, Romil reiterates his interest in and dedication to honoring students' suggestions for improving the delivery of the science material. He even offers to set up a system, whereby students could be involved in the translation of materials from one language other than English into English. This cogen is clearly capitalizing on students' inputs and helps Romil to think more creatively as to how to best meet the needs of his students.

The Value of Cogen Work with ELLs

Data from the research were used to help understand and in many cases address some of the complexities of immigrant ELL science learning. General findings throughout different phases of this research indicate that through providing many opportunities for students to talk about, share experiences, and participate in science in a variety of ways, students' transitions into the English centered science course can be better understood and changes can begin to be made. Cogens provide a very important field for this. Students help to structure the field, sharing their perspectives on how change can be made, while helping to ensure accountability.

This work can also shed light upon how the immigration experiences of students and their families are reflected in student identity and their science coursework. Several considerations are essential when planning for immigrant ELL science students. One of these considerations involves considering the cultural contexts in which science teaching and learning have occurred in the past, and the context in which it is occurring. We should understand that there are distinct ethnic cultural forms of learning science. Ethnic and other traditional practices, experiences and enactments of students play important roles in mediating student learning and participation in science classrooms. Students' ethnic cultural meanings of science are oftentimes well developed and are embedded in their individual and collective culture in the classroom. Finally, social interactions and relationships developed around science can signal power dynamics, values and interests.

Employing cogens as an important and integral component of the science teacher education repertoire of practices affords discussions and insights into important issues related to teaching and learning with immigrant ELL students. This work also demonstrates that (a) immigrant ELL students are able to access and appropriate resources needed to enact individual and collective agency and (b) more adaptable forms of teaching, learning and assessing can support a variety of ELL students (and teachers), who as a result become more capable of creating suitable structures for success.

Learning more about providing equitable opportunities in science education through the use of a multi-methods approach involving cogens, benefits not only students and teachers directly involved in the urban science classroom experience, but also has far reaching implications for methods instruction, curriculum development and educational research. By studying, analyzing and applying what has been learned through this approach, practice and praxis are catalyzed toward change.

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Chapter 10
Becoming a Science Educator | Researcher: A Personal Narrative from a Sociocultural Perspective

Konstantinos Alexakos

Coming out of college in May of 2005 with a freshly minted doctorate in my hands did not prepare me for the "publish or perish" demands of academia. At Brooklyn College, the teaching university where I started on tenure track the following September, I gained some time by publishing work from my dissertation. Still, the school had the expectation that I would establish and pursue my own research agenda. In addition to adjusting to a new work environment and demands (I had been teaching high school science prior to taking the college position) I found myself searching for a long term research agenda. My interests up to that point had been exploring science teacher identity through personal life stories. While opportunities to continue that in my new position existed, the demanding teaching load and program and student needs left very little time to start such research from scratch. Even doing any kind of educational research in general was very hard as there was also no other similar type of research going on in my department. I found myself feeling alone with very little guidance on how to proceed.

Fortunately for me at about the same time I began a collaboration that still continues today with a person that has been pivotal in my development as a researcher, Ken Tobin. Feeling alone at Brooklyn College, I reached out to him. Although we are both part of the same university (City University of New York) he was at a different campus, the Graduate Center. Through meetings of the two of us, sitting-in in his classes, and in research meetings with him and his PhD students I was deeply influenced by his notions of authenticity criteria in research (Tobin 2006), cogen (Roth and Tobin 2002) and solidarity (Tobin et al. 2005). Even more salient to my trajectory as a teacher researcher, he suggested to me that given my

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heavy teaching obligations rather than look for something additional to research I may want to focus my research on what was my work anyway, which is working with preservice and inservice science education students.

My Sociocultural Framework in "Becoming" a Teacher | Researcher

Teacher research is generally thought of as teachers exploring their own classrooms with the goal of changing their own practices, not necessarily contributing to the development of theory. What Susan Lytle and Marilyn Cochran-Smith (1992) argued is that because of their unique positioning and knowing in the classroom, teachers as researchers provide a valuable emic perspective of how knowledge is generated in the classroom. At the same time, as I discovered from my own personal experience investigating research practices as a teacher (Tobin 1999), to expand theoretical research is quite complicated, personally sensitive, and labor intensive.

Pierre Bourdieu (1992) made the case that the more we expose ourselves in our research the greater the chance we may benefit from it. This chapter is certainly aimed in that direction as a discussion of my personal process of "becoming" a teacher | researcher. My belief too is that there should be no division between the theory and the methodology in research, in my case being a researcher mediated my practices as a teacher and being a teacher framed by my work as a researcher. Like Joe Kincheloe and Ken Tobin's arguments against the oppression of crypto-positivistic epistemologies (2009), I too believe that there that there is no value free, "objective" reality, and that understanding sociocultural ways of being cannot be neutral. Consistent with Lawrence Stenhouse (1981), I also believe that teachers should play a central role in classroom oriented research, and that research in education should be of use to teachers.

I strongly believe in the need an ethical, reflexive and responsive moral framework to guide work in the classroom and that such work should be of benefit to all of the stakeholders, including the teachers and students as well as researchers. Thus, in both my teaching as well in doing research, I have adapted the use of a set of research authenticity criteria as advocated by Guba and Lincoln (1989) and later adopted and expanded on by Tobin (2006): (1) Ontological authenticity or ways in which participants including the researchers have learned by their involvement from the study as reflected in their changing ontologies and changed perceptions and enactments of social life; (2) educative authenticity or the ways in which participant stakeholders learn and understand how others view what is happening and why, and how others experience life; (3) catalytic authenticity or ways in which the research is not only done to benefit the researchers but also to bring about desired changes that benefit all stakeholders; (4) tactical authenticity or ways in which the research benefits and acts in the interests of those who, because they are disadvantaged, cannot on their own bring about desired change.

Tobin (2012) argues that learning practice and teaching practice are dialectically interrelated, and uses the vertical stroke to indicate this dialectical relationship. As I have become more interested in studying teaching and learning as a social and cultural process (Vygotsky 1978), I too see my teaching framed and mediated dialectically by my research and vice versa. In this manuscript I will be applying a similar convention, teacher | researcher, to describe my own professional practices rather than the more common method of the dash (teacher-researcher).

Spring 2007: Physics and Fictive Kinships

In the fall of 2006, I was invited to teach a physics college class for high school students the following spring (of 2007). This turned out to be my first experience in formally conducting research in my own classroom. The class met three times a week for 7 h. I recorded every class session plus every meeting after class. As the two terabyte external hard drives were still far into the future these many hours of recording meant that very week I had to burn a lot of videos on to DVDs both for storage as well as for sharing with participants. Taking notes during and after class was tough and was reduced to a few lines each meeting. What helped was that the class was held in a large classroom in which the chairs and tables were on wheels, allowing me to experiment with different seating arrangements and video recordings. But it was the students themselves who emerged as my most valuable teachers and collaborators. They readily stayed after class to discuss not only physics learning but also to open up their lives and share personal details. These experiences ultimately got me thinking about social interactions, emotions, and friendships in the classroom and how these related to teaching and learning. What became one of the most important shifts in my development as a researcher was inviting participants to be co-researchers and co-authors.

My initial view of myself was that of a critical ethnographer. While my initial interests were in exploring questions of race, gender and social class, I did not begin the research with any particular research questions in mind other than to see what came up as the class happened. Slowly through the process of exploring questions and events as they emerged, my methodology evolved to become more hermeneutic (Guba and Lincoln 1989). Who I was as a researcher also became an element of examination. It was only after several weeks into it that I became cognizant of the important role of emotions and friendships in the class but it was not until after the end of that course that I began to focus on and explore them. It was then that two student participants, first Jayson Jones and then Victor Rodriguez joined me as co-researchers and helped me frame and develop these ideas. To emphasize the strength of these friendship bonds we started using the term “fictive kinships.” This research resulted in the three of us co-authoring a very difficult piece on fictive kinships (Alexakos et al. 2011), which could not have been done without their insights and collaboration.

That I ended up investigating fictive kinships was both surprising and not surprising. Growing up in a village in southern Greece, my world was replete with "uncles" and "aunties," and "grandmas" and "grandpas" most of whom had no family relationship to me either by marriage or by blood. I was also raised in New York City where being called "brother" was a strong term of endearment and friendship. It was a happy place for me to be as an instructor and as a researcher and just another example of how, in a very recursive and dialectic process, our identity (Stetsenko 2009) mediates not only what we research but also how we do our investigations and what understandings we walk away with. As I became more comfortable with hermeneutics, I became more comfortable with researching events as they happened in my classroom. This was another defining moment in my transformation as a teacher | researcher.

Deciding When to Do Research as Well as Teaching

Being a teacher | researcher is very labor intensive. In addition to what is expected of us as instructors (preparing and teaching the subject matter, responding to student needs and concerns) and as an education faculty (mentoring and advising students, attending the countless meetings, and doing curriculum changes and responding to certification requirements) researching my own classrooms also meant putting much more time into setting up for recordings, meetings with the study participants, and preparing and reviewing video. In addition, there is the personal aspect. As a new faculty member what little previous research experience I had was the research I did for my dissertation. That research (Alexakos 2005) included interviews with other science teachers but not investigating my own teaching. As I started to research my own teaching I felt very vulnerable to outside critiques, especially as video creates a somewhat permanent record of what we do in class, including documenting what may be used by others to personally discredit us. The first few times I watched videos of myself teaching my first reaction was to look at myself; the way I walked, the way I talked, and how I sounded. It was only after I got more comfortable with having myself recorded and displayed in the video that I truly began to look in a phenomenological sense at the rest of the class and the interactions among and between participants. Student participants were already familiar with how I taught, so reviewing with them video clips and getting their feedback was not that much more of a leap, as it was understood that it was to be constructive and not hurtful. With this class, these students were very welcoming and kind. As they became more comfortable with me and realized that I really meant it when I said that I cared, they stayed behind to talk and share their stories and thoughts. The framework for conducting these discussions could be labeled as "cogen" (Roth and Tobin 2002) but in those days it was just what I did to make participants feel welcomed, notwithstanding the perceptions concerning the difficulty of the subject matter (college physics). Thanks to their humor and good will I looked forward to doing that work despite not having any additional reassigned time for this research.

Growing as a Teacher Though Self-Research

Besides our work in the classroom and my growth as a researcher, my experiences in the spring 2007 helped me grow as a teacher. I was amazed that even little things we say as teachers can have a big impact on the students. From this research I became more cognizant of the stereotype threat (Steele 2010) and its possible implications. These students were very sensitive to the use of negatives in the classroom. For example, at the beginning of the course I had mentioned that a large percentage of students in a typical first semester college physics course fail the course, but since my class was taught by me that would not happen. As I began to get to know the students, to my surprise what several students brought up on their own was that this statement made them feel that they would end up in failure as well. This occurred despite my intention that they would hear that I cared that they were successful in my class and would do my best to assure their success. Another negative example was the way the beginnings of teacher questions are commonly phrased such as, "Can anyone tell me …" or "Does anyone know …" I became aware that by phrasing them as such it implied a deficit perspective on how students are thought of; that these students held a greater negative value than I would have thought. By asking them in this fashion they understood that it was not expected that they would know or not expected that they would share if they did. As a result, since then, I have been conscious to frame my questions in a positive sense, such as, "Who will…" or "Who knows…" As I share these lessons with the teachers and teacher candidates in my classes, I find that these negative ways of asking questions are very habitual with them and it is difficult to change even though they try very hard to change.

Changing the phrasing of my questions was not the only impact this work had on my teaching. As a result of me slowly understanding how important friendships were in class, with the input of the students involved I changed their seating so that friends were in closer proximity to each other. When they got stuck or had questions with a particular physics problem they could ask their friends for help. I also realized how important emotional support and mutual encouragement was for them especially when under stress which when studying physics in college for the first time can be often. By being allowed to be near each other and communicate throughout the class made it that much more possible for students to persevere and succeed.

Another lesson that was of a great shock to me was that as teachers we do not realize how much we miss of what is going on in our classrooms. I had thought that I was very good at being aware and paying attention to what was going on in class, especially since I video recorded each meeting. A few months after the semester was over, I was having coffee with Jayson and Victor and talking about the role of laughter in their class. That is when they told me about the hand signs and verbal exchanges the kinship groups were using to communicate with one another. Not only had I not been aware that this was going on, but they literally had to slow down video clips frame by frame for me to catch when this was happening.

While the above lessons were very important to my development, it was our sociocultural work with friendships that has framed my epistemology since. The close intimate friendships (that so much resembled those of kin relationships we termed them "fictive kinships") that existed in the classroom were vital in the wellbeing of the students involved. Not only did these bonds mean support for each other with the academic work in class, but they also affected their perseverance in the physics course as well as their perseverance in basic things like coming to school and making it through life, which for many was very challenging.

Spring 2008: Learning from My Own Emotions

The following spring (2008) I was assigned to teach a second college physics class for high schools. By this time I was becoming more proficient on setting up the mikes and video for recording. At the same time the class had a different personality and while it too was very welcoming, students did not become as interested in the research work as the previous class. Still, the following year when two of these participants chose to continue as undergrads in my college, the three of us met regularly to talk about their experience. Both of these students were young women of color and both were majors in science. The three of us considered doing a study on their experiences as science undergrads and I even applied and received IRB approval for it. Though this did not develop into being written up, our meetings also took on the role of a support group, which I think was quite useful given the many challenges and biases they faced (not only as science students but as women of color). These discussions further concretized the importance of addressing social justice in teaching and learning and gave me further insight into how complicated and social is the process of learning.

The next step to that was to share the videos with colleagues for feedback on particular questions. This was much tougher as my own teaching was now on display to be judged and critiqued, not a comfortable feeling at all. There was one incident in particular that took a lot for me to share with others. At one point in my spring 2008 physics class, I had gotten angry with my students but had not realized it. It was only a few weeks later as I was reviewing the videos that I came across it and became cognizant of my angry demeanor at that teaching moment. I went back to the class and apologized to them. Talking with Ken Tobin about it we decided, though I was still pretty nervous about it, to have him and another close colleague, Jen Adams, come and have a discussion with the class about it. This was not easy as now this sordid incident would become publicized beyond the confines of my walls. I remember another close friend telling me to just destroy the tape and forget about it given how it may be used against me (I was still on tenure track). But trust these colleagues I did and they ended up having a nice discussion with the class. The class did not think it was a big deal and had clearly moved on. For me though, it was a point to introspect my teaching and become more mindful of such negative emotional responses. More than once I have caught

myself beginning to feel similar emotions and recognizing them I now can step back and modify them.

Although not always being able to modify my emotions while teaching up to this event I was very confident that I was very aware of my emotions. Viewing a video of this event shattered that illusion. As I reflected on what may have framed the conditions for me to lose control of my emotions and to be unaware of it, I realized that the event occurred on the heels of some very stressful events. I had just returned from being away from my family for a conference, came back sick, and then had to do my taxes-an act that generally leaves me dispirited. Understanding these and then remembering how I felt emotionally as I was building up to becoming angry made me more mindful of how it feels as I am getting angry and thus allowing for interventions to minimize or prevent uncontrolled anger from happening. It also made me aware of the many times teachers may become emotional without even noticing it, even when the expression of intense emotions may have severe negative consequences. Having the benefit of reviewing such events by catching them on video greatly helped. Coming to terms with this incident helped me feel more confident with my own teaching in the classroom. It also became part of my teaching to new and prospective teachers, making them more aware of the role and effects of positive and negative emotional climates and experiences in teaching and learning. These insights and the need for interventions to attenuate unwanted teacher and student negative emotions in many ways have paved the way to our investigation of emotions in the spring of 2012.

Spring 2012: Collaborating on Emotions and Mindfulness

Ken Tobin and I had been discussing how to collaborate in research in the classes I taught for a while. In the fall of 2011 we decided that the following spring (2012) we would use a graduate science teacher education course I was to teach on the history of and issues in science and science education for a study on emotions. While some of the research focus was to be on themes and methods I was somewhat familiar with (e.g., radical listening, cogen, coteaching, emotional climate) Tobin also proposed exploring other topics such as mindfulness and using physiological measurements and interventions which at that time I had only vague, abstract ideas about. Adding to the challenges was that much of what we put together had never before been researched in the classroom. What little had been done on emotions was just then being tried out by Tobin and some of his collaborators in Australia (Tobin and Ritchie 2012). Though some of the interventions and data collection (like cogen or wearing oximeters) would have little potential impact on class time or the curriculum, others, like using clickers every 5 min to click on experienced emotional climate, had the potential of becoming very disruptive, and thus of utmost concern to me as the class instructor. As it turned out, the clickers were very much liked by the students and we used them throughout the semester, even longer than originally planned (as the students themselves wanted to keep using them).

By this time, as a result of my previous work, building a sense of community in my classrooms had become a priority for me. The question then became how to do it. After reading Tobin's introduction to a book on the key works of Joe Kincheloe (Tobin 2011) radical listening became for me an important instrument in accomplishing this. The epistemology framing radical listening is that room is made for others' viewpoints, but more radically, that difference becomes a valued source of learning. I first introduced readings on it to my students during the fall of 2011 semester and began to work with them in encouraging such discussions in class. The spring history of and issues in science class has always been contentious and emotional and I had wanted to set up an environment where students felt encouraged to participate and their views respected.

This was especially so for the topics of gender and evolution for example. When presenting on gender the coteachers discussed issues of gender in the classroom and how teachers may make it more welcoming for all students. One of the coteachers felt comfortable enough to share with the class that he was gay and discuss some of his own experiences with equity and discrimination. The class on evolution too was very emotional. It was also for many of them, even for those that had a biology undergraduate degree, the first time they had a chance to discuss personal issues and conflicts and a chance to encounter and learn from each other's views and beliefs across a spectrum of different beliefs. Students expressed an appreciation for the discussion not only because it allowed them to think of their personal beliefs but also as they would also be faced with teaching students with similar beliefs and conflicts in their own classrooms.

Like my work with fictive kinships, this research on emotions and mindfulness reflected my "inner core" interests and identity professionally and on a very personal level. One my primary concerns as a teacher educator has been the stress and emotional difficulties faced by new teachers. Teaching is a very difficult profession and made even more so by present-day demands on the profession. As a result of our research many of the graduate student participants began to become more mindful of their emotional states, especially of unwanted negative emotions like stress, and used breathing meditation in their own classrooms and in their personal lives to help them and their students improve their own wellbeing and the wellbeing of others around them. I do also.

The Use of Heuristics

I have found that no matter how comfortable I may feel with the open-endedness of ideas (and hence of hermeneutics), many of my students still prefer to have something concrete that they can use as a reference and for guidance. Having the heuristics provided that concreteness. For example, through the use of heuristics as an intervention to help students become more mindful, their input and feedback enabled us to adapt and modify the heuristic to better fit their needs as well as refine it as research tool for landscape studies of mindfulness.

Coteaching happens in different forms. Most often, when I discuss it with my students, their first thought is about two teachers coteaching in the same classroom, such as a science teacher and a special education teacher in an inclusive classroom. In the past, Roth and Tobin's work on coteaching (2002) had looked into a variety of coteaching arrangements, including the researchers coteaching the class they were researching and student teachers coteaching with more experienced classroom teachers. What was different in our spring 2012 class was that it was the students in groups of two to four who cotaught each lesson. While their lesson was prepared in consultation with the instructor (I), these coteachers were responsible for teaching the topic. From previous semesters it had become apparent that something like how to coteach had to be taught to these graduate students. While I may have had ideas on how collaborative work was to be done, I had no framework to teach them how. Even in my own personal experiences as a graduate student, working with others to do group presentations had been very mixed, some very nice and some very stressful. The heuristic on coteaching allowed me, as the instructor, to provide students with a framework for how to coteach, while also using students' responses and feedback for our research on coteaching.

The same was true for the radical listening characteristics found in the coteaching heuristic as well as in cogen and dialogic inquiry heuristics (Alexakos and Tobin forthcoming). Though radical listening did not make the classroom absolutely "safe" for the kind of very emotional and challenging discussions we had on topics ranging from race, gender and social class to evolution and eugenics it did encourage students to share their views and learn from each other. Some of these emotional moments and the enactment of radical listening are taken up in an article I coauthored with one of the coteachers of the class on evolution (Alexakos and Pierwola 2013).

Continuing as a Teacher | Researcher

Being active in research that has direct applications into my students' own teaching and learning has helped transform our science education program. The cohort that was part of the spring 2012 research felt greatly enriched with the experience of being involved in "real" classroom research. The students in the new cohort that began classes this fall (2012) too have been very interested in applying what they are learning about emotions into their own teaching. This fall (2012) I made the coteaching heuristic and the heuristic that became the dialogic inquiry heuristic an integral part of the curriculum of the graduate adolescence science program that I am the coordinator for, not only to provide students with a framework to carry out such activities, but also to help their own students understand how it may be done. The hardest part has been convincing these inservice teachers and teacher candidates that coteaching can be viewed as done not only by them as teachers but their students in the class, that it is important that their students are seen as coteachers.

This has been quite hard and it feels like it requires a total paradigm shift in how teaching is thought of in a classroom setting. Interestingly, the new teacher evaluations for New York City teachers, Charlotte Danielson's *Framework for Teaching* (http://schools.nyc.gov/Academics/CommonCoreLibrary/ProfessionalLearning/TeacherEffectiveness/default.htm) assess for many of the characteristics that our heuristics emphasize and has made the implementation of the heuristics all that more valuable and necessary.

Some Considerations for Preparing to Do Research into One's Own Classrooms

As the spring 2012 work was my first time working with an "official" research squad who were Ph.D. students, not students from my class, there was an added learning curve for me. Initially I thought that their role was to help Ken and me, but as the research progressed I realized that it was the other way around. Besides Ken and myself, almost all of the remaining research squad had no prior educational research experience. In addition, the research itself was cutting edge with the many of the methods emerging as we were doing the research and learning from it (like the use of heuristics and timers to synchronize various recording devices we were using). Until these Ph.D. students began to emerge as researchers who could work independently on their own, much time was spent teaching them about collecting and working with data, even during class time, initially posing conflicts with my time teaching, which thankfully we mostly worked out quickly.

During the spring 2012 research, controversies did arise in the class with the students and researchers, such as balancing of class time spent on the official curricula with time in class spent on research, and what constituted research and what constituted course content. Because of such potentially research initiated disruptions, my coresearchers and I needed to be sensitive to and attentive to any emergent issues and head off possible problems. This was done by talking with participants before and after class, individually and in cogen, as well as having whole class discussions as to how we were doing the research, what was emerging. We thus made it a priority to invite participants regularly for their inputs and concerns and to use these contributions to guide and modify our research agenda.

Instructors who wish to carry out research in their own classroom will benefit from preparing their students in advance to participate in the research. This includes discussing benefits in participating especially with the option of becoming co-researchers and coauthors on papers and learning about research through doing research. Having student participant support for the research is a must. Following the authenticity criteria makes it a lot safer and non-intrusive for both the instructor-researcher and students. When conflicts between teaching and research come up in class, classroom researchers need to have some prior established procedure of resolving them. For example, some of the conversations may be too sensitive for the researcher in her or his position as the instructor to be part of. In that case, others

(working with the instructor-researcher) could lead such discussions with the understanding that the instructor will not view the video until after the semester is over and the grades have been entered. In addition, our school's Institutional Review Board (IRB) has been very sensitive concerning the recruitment of our own students to participate in the research. One resolution has been to have other researchers from the squad distribute and collect the student consent forms. Since some of the students in the class are also IRB approved co-researchers this solution was an easy resolution. Other difficulties could involve what to do with students who not only are not interested in participating but may also object to any video recording of the class even when it is part of normal class practices and is part of the syllabus and curriculum. Even for students for whom this is okay, being videotaped can make their experience a bit more stressful so it is very important to make the video available for them to review and use. Possible benefits include using class videos to improve their teaching practice, learning about research in their own classrooms, and doing research on their own learning as graduate students. As mentioned earlier, it is crucial that the classroom instructor has the final decision of what is done research wise during class time.

Research Re/shaping Teaching and Teaching Re/shaping Research

As I write this chapter I realize that my work as a teacher | researcher had its start when I was still a high school teacher. It was then, before I had done my Ph.D., that I started to publish articles from my own experience teaching science in high school, including work on issues of gender and physics learning (Alexakos and Antoine 2003). My research work at the university level, first with the physics students and now with emotions and science teachers, has come more and more into sync with my personal beliefs and interests in social justice and equity, especially pertaining to race and social class.

Similar to my research aligning with my interests, my methods of research have likewise been transformed from seeing myself as simply an ethnographer, to embracing the openness of hermeneutic phenomenology. My research and emerging findings change in tandem with each other, in a continuous spiral of the two framing and mediating each other. Together they reshape my own teaching as my teaching too reshapes my research and my understandings of emerging findings in this dialectical process. Framed by the authenticity criteria discussed earlier, I have become convinced of the importance of inviting participants to identify what they think are highly salient events and co-construct what is going on and through their empowerment and participation as coresearchers.

In the process of being a teacher | researcher, I have become more confident with my students, trusting them as a community of support. Often I find myself stopping a lesson to discuss something novel that may have just happened or to reflect as to what or why something took place. I may have been the teacher in these classes

but it was they, my students, that challenged me and taught me how to be more reflective and more effective as a teacher and a researcher. By helping me feel more comfortable and welcomed into that classroom space, I became more comfortable about researching my own teaching. Along the way, my eyes have been opened to how important relationships and sense of belonging are to learning. As these understandings emerge, I reflect back to my own learning. I too remember the difficulties I faced when I did not have such friendships or feelings of belonging. If it were not for my friendships, as an undergrad for example, I would have probably never graduated.

Meanwhile, both Pierwola and I continue to interrogate (and argue) further about what "safe" meant to students in the class, what radical listening is, how and when to apply radical listening, and its benefits and limitations. Another of the coteachers of the evolution topic too has become interested in the investigating elements that went into creating a community in that classroom. Since the spring 2012 course finished, a third student, who is new to the program has begun investigating coteaching in the classroom this semester (fall 2012). For these three graduate students their research papers will also be their master's theses. Together, the four of us have been meeting every week to discuss our research and support one another as well as continuing to collaborate with the other researchers in our research squad.

I believe that my investigations of enacted teaching and learning practices have been beneficial to my students. At the same time these explorations have provided rich research opportunities for me while sharpening my understandings and improving my skills as a science education teacher. As I teach, I share these insights with my students and encourage them to investigate and explore the role of emotions and emotional bonds in their own learning and teaching. Bringing research into my teaching and my teaching into research has enriched both.

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Part II
The Virtual and the Real in Education Research

Chapter 11
Conceptualizing Identity in Science Education Research: Theoretical and Methodological Issues

Lilian L. Pozzer and Phoebe A. Jackson

Science education researchers are increasingly relying on the concept of identity to understand how students and teachers learn and participate in science. Identity has proven particularly useful for theorizing the relationship between individuals and their social world. Accordingly, it is often used in sociocultural studies that explore issues of equality, marginalization, and underrepresentation in science education (e.g., Malone and Barabino 2009). Identity as a theoretical and methodological tool has been used not only to demonstrate that certain groups of students continue to be marginalized in school science, but also to find ways to overcome such marginalization (e.g., Rahm 2008). As identity gains prominence as a theoretical and methodological tool, it is evident that there is disagreement about how it should be conceptualized (Shanahan 2009). For example, some researchers view identity as something individuals possess, while others consider identity as existing only in and through interactions, thereby being constantly renegotiated. The issue, however, does not lie in the fact that different researchers have different ways of conceptualizing identity—each conceptualization can be useful when applied in an appropriate research design. The problem arises when researchers mix and match theories of identity without sufficient attention to its philosophical underpinnings, which frame identity in particular ways that are better suited for specific methodologies and research designs. The diversity of identity theories in the literature makes it difficult for

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researchers to choose between different ways of conceptualizing identity and to use identity in a consistent manner, particularly for those working in a field where identity is a relatively new tool, such as science education. Indeed, it is not uncommon for science education studies, whether intentionally or unintentionally, to couple diverse and, at times, even contradictory definitions of identity without sufficient justification, exposing their results to criticisms of theoretical and methodological weakness.

In this chapter we discuss some of the identity-related theoretical and methodological problems found in science education research, highlighting the most common theoretically contradictory uses of identity and the inconsistencies between theory and methodology that may arise in some cases. Prior to discussing these cases, we introduce a conceptual and analytical framework that conceives of identity either as possessed by the individual or as constructed and negotiated in interactions. We also discuss these two ways of conceptualizing identity in terms of their potential for sociocultural research on science education.

Laying the Groundwork

The impetus for writing this chapter grew out of ongoing discussions in a science education research group at McGill University. Our group met weekly to discuss various readings as well as our own research. Each semester the readings focused on a theme in the domain of sociocultural research that addressed issues of equity in science education. These discussions often centered on issues related to identity, as various members of the group were engaged in identity related research at the time. Throughout the readings, we noted conflicting uses of identity, both across and within articles, and found ourselves struggling to use identity in a coherent manner in our own research. This led us to carry out a literature review of the use of identity in science education. The results of the review, along with an analysis of theoretical and methodological coherence in the reviewed papers, were presented at a symposium at the 2010 National Association for Research in Science Teaching (NARST) conference (Abraham et al. 2010).[1] A summary of the literature review and the accompanying analysis is given in the next section.

During the symposium, our group engaged in further discussion with the audience about the difficulty in conceptualizing and using identity in science education research, which prompted us, the authors, to continue reading on and debating this issue. Although we do not purport to have arisen at any definitive approach to identity in science education, we present here our current understandings of this issue and suggest ways to avoid problems in research when using identity theoretically and methodologically.

[1] We would like to acknowledge the other research group members who contributed and co-authored the NARST symposium paper with us: Anjali Abraham, Mariusz Galczynski, Allison Gonsalves, Stephen Peters, and Gale Seiler.

Identity in Science Education Literature

The literature review included 91 original articles published from 2000 to 2009 (online publications included) in any one of the 10 science education journals that presented the largest amount of publications on identity (Cultural Studies of Science Education; International Journal of Science Education; Journal of Elementary Science Education; Journal of Research in Science Teaching; Journal of Science Education and Technology; Journal of Science Teacher Education; Research in Science Education; Science Education; Science and Education; and Studies in Science Education). Of these 91 papers, 46 focused on student identity, 36 focused on teacher identity, 5 looked at both student and teacher identity, while 4 were not focused on student or teacher identity. Approximately three-quarters of the student-centered articles addressed issues of equity, focusing on either racial/ethnic or gender differences, confirming that identity is an important tool for researchers seeking to increase the science opportunities of marginalized students. Such studies tended to use identity as a lens through which to better understand science engagement, learning, or participation of students from underrepresented groups, often with a discussion of how such situations can be improved. Despite the predominance of equity-related articles, none addressed non-race or non-gender issues of underrepresentation, such as sexual orientation or learning disabilities.[2]

In contrast to the student-centered articles, less than one-third of teacher-centered articles were devoted to issues of equity. Of these non-equity based, teacher focused articles, the majority explored the process of becoming a teacher, most often referring to this as developing or constructing an identity as a teacher.

The large majority of authors explicitly classified their methodology as ethnographic and/or comprised of case studies, but there was also a wide range of other qualitative methodologies, including participatory research, hermeneutic phenomenology, and grounded theory. Methods of qualitative data collection covered the full range of approaches including reflective journals (by both participants and researchers), audio-recorded interviews and focus groups, observational field notes, and audio and video recordings of classrooms. Although interviews were most frequently used, over one third of the articles also used video-recorded data, which is a larger than usual proportion for science education research. Eight articles used some form of quantitative analysis, specifically surveys, pre-post testing, and scored interviews. However only three of these articles applied a quantitative methodology to measure identity, while the other five applied a qualitative framework in relation to identity. Of those that did quantitatively measure identity, all three used surveys to do so. Six articles were not research reports, including three theoretical articles and three literature reviews.

[2] This gap may, at least in part, be coming to the attention of researchers, as evidenced by Bazzul and Sykes' (2011) recent article which addressed issues of identity and the exclusive promotion of heteronormativity in biology textbooks.

Conceptualizations of Identity in Science Education Research

One-fifth (18/91) of all articles reviewed did not attempt to define identity despite using it as a methodological construct. Those that did define identity used a wide variety of theoretical frameworks, ranging from identity as something that can be carried with an individual into different contexts across space and time, to conceptions of identity as an unstable construct existing only in interaction. Many articles presented the concept of role identity[3]—where people occupy specific roles in certain contexts, whereas other articles used the concept of discursive identities—where identity is constructed through, and shaped by, discourse. However, even when the same term was used, the theoretical and methodological framings varied drastically across papers. For example, some authors used the term role identity in the context of people as a collection of role identities, where each identity has salience in certain contexts and thus comes to the forefront only in certain situations, otherwise residing in the background. Others used the same term, role identity, in the context of people temporarily occupying socially defined roles, where these roles exist externally to the person, and the identity is constantly negotiated, rather than carried within the individual. Although these two conceptualizations of role identity seem similar, they encompass significantly different theoretical approaches to identity. These theoretical approaches have repercussions in the research design (i.e., questions, objectives, methods of data collection and analysis), which we elaborate on in the following sections.

The most common theoretical framing of identity found in the review was a highly dynamic perspective, in which identity was said to be in constant flux, contextually situated, constructed only within interactions, and/or continually under negotiation. In contrast, no articles considered identity to be fully stable across time and contexts. However, many articles did theoretically frame identity as being relatively slow to change, framing identity as a cumulative, or layered characteristic of a person that develops, forms, or shifts over time due to a string of events and interactions. Such a perspective allowed for identities to be carried with a person across situations. Lastly, another sizeable group of articles professed a theoretical framework that fell between these two viewpoints (dynamic vs. relatively static), or that combined aspects of the two.

Inconsistencies arose when many of the articles that theoretically framed identity as dynamic, constantly changing or being negotiated, alluded to a more stable definition of identity in their methodology and/or elsewhere in the paper. For example, quite a few authors referred to individuals *possessing* multiple identities, with different identities surfacing in different contexts. In the case of multiple identities within an interactional framework, only a few authors were able to maintain consis-

[3] Interestingly, despite Turner's (2002) influence on the concept of role identities, his work was only drawn on in relation to identity by two authors in our review.

tency by explaining that a discussion of multiple identities did not mean that individuals kept a host of identities with them everywhere they went. Rather, it meant that people were recognized as different types of people in different situations, but such recognition was always under negotiation.

To assist future research in recognizing and therefore hopefully avoiding problems related to the use of identity, our original analysis of the reviewed articles discussed the three most common inconsistencies: (1) identity was theoretically framed as being both something that is carried with an individual into different contexts, and also as being continually produced through interaction. While it may be possible to merge these two seemingly conflicting perspectives on identity into a coherent framework, the problem arose because most authors combined the two views without providing an explicit justification for how they could work together; (2) identity was theoretically framed as being continually renegotiated in interaction, but the methodology used was aligned with a view of identity as a more static concept; and (3) identity was theoretically framed as being continually renegotiated in interaction, but choices of language throughout the paper referred to identity as something that is carried with an individual into different contexts.

In the original analysis of the literature review, our group discussed these inconsistencies (which we referred to as incoherence) in terms of an *identity continuum*, whereby identity could be conceptualized, at one end, as a static construct, and at the other end, as a dynamic, unstable construct. Several science education researchers have proposed other ways of interpreting the range of identity conceptualizations. Shanahan (2009) suggested that identity should be analyzed both on the individual and on the societal levels, while Lemke (2000) proposed that identity can be conceptualized differently depending on the time scale in question. Shanahan's point is very interesting in terms of research on equity issues, as it emphasizes the need to consider the broader social context, particularly social structure, when discussing identity construction. Identities do not exist as isolated constructs in the minds of individuals. Identities are co-constructions, inextricable from both the individuals and their surroundings and relationships. Students do not and cannot construct identity at will and out of nowhere. They are constrained and guided by the possible identities in the social situation. Society does not, however, wholly define identities.

Shanahan framed identity as constructed in interactions with others, which fits into a more dynamic and negotiated approach to identity. However, Shanahan's review does not focus on the theoretical underpinnings of different perspectives on identity, but rather on the unit of analysis of the research (individual or social). Therefore, although Shanahan's work implicitly endorses the argument that there exists a need for increased consistency between theoretical and methodological approaches to identity in science education, it does not explicitly make such a case. Accordingly, it supports rather than overlaps with the work presented in this chapter.

Similarly, Lemke's (2000) time scale distinction offers important insights into different ways of conceptualizing identity according to the unit of analysis used in the research (in terms of micro or macro timescales), which merits close attention. However, we found that most articles often looked at identity over similar time scales, but with very different theoretical perspectives. Thus, the static-dynamic continuum provided a better framework to analyze these articles, although as discussed in the next section, it was only a stepping stone to an improved framework: the possession-negotiation framework.

An Alternative Framework for Discussing Identity

While the static-dynamic continuum was invaluable to our group's original analysis, it was also problematic. As mentioned, none of the reviewed papers presented a purely static view of identity. Even when authors referred to a core identity, which was fixed and stable within the individual and could be carried around across contexts, they also claimed that other elements or aspects of identity changed over time, in a cumulative process. The notion of multiple identities was also difficult to place within the static-dynamic continuum. While individually each one of these identities is a static construct, the possibility of choosing an identity according to context or the notion of gradation of salience among one's multiple identities according to different contexts implies a level of dynamism, even if not exactly on the construct itself, but rather on how identity is manifested during interactions. Therefore, the continuum resulted in a lop-sided spectrum with no articles on the completely static end, as well as several articles that were difficult to reliably locate on the continuum.

Insofar as the definition of identity as either static or dynamic was essential to our group's discussion of the inconsistencies we have pointed out, the need to refine the continuum so that contradictory conceptualizations of identity could be more easily exposed and discussed became acute. Accordingly, we decided to propose an alternative analytical framework that would propitiate further exploration of the theoretical and methodological inconsistency of identity use in science education research. In the next sections, we expand on this alternative framework, which we used as both a heuristic and conceptual tool to discuss issues in theorizing and analyzing identity in science education research. Please note that we will not provide specific examples of inconsistencies found in the reviewed articles, as our intention here is to open up a debate around the use of identity in science education research, particularly with respect to what we here consider to be distinct theoretical approaches to this construct, rather than censure or negatively expose the work of authors we respect.

Possession vs. Negotiation

An alternative way of making sense of the diversity of conceptualizations of identity available in the literature is to consider whether identity is *possessed* by the individual or *negotiated* during interaction. The *possession* approach to identity is more stable and static than the *negotiation* approach; however, it still allows for changes in identity over time and across contexts as a consequence of interactional patterns, life experiences, structure|agency dialectics, etc. If one possesses an identity, that identity can be *carried on*, *brought into* an interaction, *foregrounded* or *backgrounded* in different situations. The main idea here is that identity has at least some fixed properties that define oneself regardless of where we are or with whom we are speaking. Thus, the notion of *core identity* is an example of the possession approach to identity: individuals possess a core identity, which, once established, is difficult to change. The core identity is stable enough to be carried across contexts, even if it does change somehow (either as the result of a cumulative process, or in terms of other elements of identity changing while the core remains stable). This approach is exemplified by Gee (2000).

The notion of *multiple identities* also fits the possession approach, where every person possesses a host of identities (usually defined in relation to particular societal roles). Which of these identities is salient at a given moment depends on the interactions and contexts within which we interact; thus, we can be mothers, daughters, doctors, spouses, scholars, teachers, students, Canadians, Catholics, feminists, neo-liberals, middle-class, etc., all at the same time, but with salience placed on one particular identity at a time, depending on the context of the interaction. Making one of these identities salient during a particular interaction does not undermine the fact that we also possess all the other identities we may make salient in other interactions or situations. In this sense, the context determines which identity (or role) is most salient and thus comes to the forefront while the other identities remain in the background.

The important concept here is that we *possess* all these different identities; they reside within us and share the same thread (that is, the same core). These multiple identities differ in the social role we play in various daily interactions, but they are all instantiations of the same self in different situations. Thus, the idea of *role identity* also fits within the possession approach, inasmuch as these roles are conceptualized in terms of pre-existing identities or aspects of one's identity that are expressed or enacted in different situations. Various studies in science education used the role identity model to refer to students and teachers in schools, where their *academic identity* or *teacher identity*, respectively, was brought in contrast to or in substitution of other identities they possess. Thus, in many cases, a possession approach to identity conceptualization conceives of the different roles we occupy in society as an individual's identities, which coexist but are not necessarily emphasized in every social interaction.

Within the possession approach to identity, change is possible in terms of which identity or aspect of our identity will be expressed or become salient in any given situation, and also cumulatively with time and experience. However, the notion that the identity or identities are pre-existent and reside in the individual remains unchallenged.

The opposite approach to possessed identity is the *negotiation* approach which views identity as something we construct in interaction, and therefore, as something that must be continually reconstructed: "The process of identity construction does not reside within the individual but in intersubjective relations of sameness and difference, realness and fakeness, power and disempowerment" (Bucholtz and Hall 2010, p. 27). The negotiation perspective does not support the notion of a core identity, but rather, identity must be continually renegotiated in each new interaction. Who we are—our identity—is a direct result of the fact that we are always an *other* to somebody else; in Ricoeur's words, "the selfhood of oneself implies otherness to such an intimate degree that one cannot be thought of without the other" (1992, p. 3). Therefore, the process of identity construction always involves some form of identification, counteridentification, or disidentification (Medina 2006) with a particular group or groups of people. We frame or construct our identity in relation to others in a continuous process of identifying similarities and differences with others. As Mead puts it, "the individual is an other before he is a self. It is in addressing himself in the role of an other that his self rises in experience" (as cited in Medina 2006, p. 65). Thus, we do not possess an identity or any part of it independently of our interactions with others; it is in and through interactions with others that we become *a self*, that we construct identity.

Within a negotiation approach to identity conceptualization, social roles are conceived as socially established available positions that one can occupy or try to occupy in society, rather than identities in and of themselves. In this way, social structure and recognition by others become important elements in one's identity construction. As Medina (2006) argues, certain stereotypical identity models are fixated and privileged in society, so that certain ways of being are deemed, accepted and perpetuated as better than others, thus holding more symbolic or actual power. Not only can people refer to themselves in terms of these stereotypical identity models, but they can also use these to label others and determine their social value. Although individuals may perpetuate these stereotypical identity models, these are not individually created and they do not reside in the individual. They can be seen as structure that constrains individual's action possibilities in society, including identity construction and negotiation. In this sense, these stereotypical identity models might refer to social roles assigned to individuals or even aspired to by individuals, but they are not identities; rather, they are socially produced models that influence identity construction and negotiation. Thus, a social role as an identity possessed by an individual is distinct from a socially established stereotypical model for identity construction and negotiation. The former has been used in science education research to discuss, classify or analyze one's identity in a particular situation or context as a more or less stable part of who one is; Whatever role we play in interaction is viewed as a (quasi-) permanent and defining part of who we are rather than a part of the process of constructing and negotiating an identity in interaction, as the latter implies.

Similarly, the notion of taking up or appropriating identities implies a pre-existing identity that must be stable enough to be transferred across contexts and therefore available to the individual. What remains unexplained in most theoreti-

cal approaches to identity appropriation is a discussion of from where exactly one takes up or appropriates an identity. If a distinction between social roles or stereotypical identity models and an individual's identity is made as we did above, then the issue of appropriation becomes a little clearer. For instance, if we consider that stereotypical identity models are made available to individuals during interaction, then one may appropriate such model (or role) in any given interaction. However, the process of negotiation with others is still crucial to this way of conceptualizing identity. To construct our identities we need *to be seen and accepted by others* as a certain type of person. This legitimizes our identity claims during interaction and effectively constructs our identities during each and every interaction. In the same way in which we are constantly identifying or counteridentifying with groups or individuals, others are always doing the same in relation to us; thus, in the course of interactions with others, one negotiates one's identity and may also reify group memberships. In this sense, identity is necessarily "*heterogeneous*, based on diversity" and "*unstable*, subject to fluctuation" (Medina 2006, p. 86); it is in relation to a multitude of others that the self comes to be, so that heterogeneity and instability are inherent in the concept of identity. Here, we see that the negotiation approach to identity allows neither for identity stabilization over time or contexts, nor for the existence of a core identity or for the possession of one or multiple identities by individuals. All identities (and any parts, elements, or aspects of it) are always negotiated with others in interaction; whatever *dispositions* we bring with us to an interaction do not constitute our identity—we are not defined by the way we speak, the clothes we wear, or the car we drive; these attributes can only *identify* us in relation to an interactional context where identification or counteridentification with others takes place. Even if we claim an identity during an interaction (as, for example, in trying to *impersonate* a stereotypical identity model available in society), whatever identity we construct during this interaction will be a result of a negotiation between our claim or attempt at an available stereotypical identity model and whether or not others recognize, accept and legitimize it.

The negotiation perspective on identity has also been referred to as *performed* or *performative identity* (e.g., Joseph 2010). In this sense, performativity is closely related to discursive identity—every discursive action achieves more than the strict communication of linguistic meaning; it also displays something about the sort of person the speaker is; that is, the discursive act indexes an identity (Johnstone 2010). This indexical relationship is what generates, in our opinion, some confusion about what it is that we bring into interactions, and what it is that we take with us from interactions. According to the negotiation approach to identity, identity cannot be fixated or stabilized—it is always unstable and always constructed and negotiated in interaction. But there is something (which we here refer to as *dispositions*) that we do bring into interactions and carry around with us; these dispositions may be used for defining aspects of selfhood during interactions, but they are distinct constructs from identity. Various authors have articulated concepts that refer to that which we bring with us into interactions, and which also displays membership to particular groups and associations to established social roles (e.g., Bourdieu's (1977) *habitus*;

Ricouer's (1992) *character*; Sewell's (1992) *schemas and resources*; Swidler's (1986) *cultural toolkits*). Whatever construct we use, it is important to distinguish these from one's identity.

Application of the Possession and Negotiation Framework to the Literature Review Data: Discussing Theoretical and Methodological Issues

As previously discussed, the original static-dynamic continuum was too unwieldy as an analytical framework, which led us to replace it with an alternative framework that allows us to more easily discuss the theoretical and methodological issues we found in the science education literature on identity. Accordingly, we revisited 90 of the 91 reviewed articles (we excluded one literature review which expressed a multitude of identity frameworks) and classified them according to their theoretical stance on identity as either adopting the possession approach or the negotiation approach to identity. In the end 24 papers fit the possession perspective, 31 tended towards the negotiation perspective, and 17 drew from both the possession and the negation perspectives, resulting in a third category we termed *combination.* The remaining 18 papers, as previously mentioned, did not make an attempt to theoretically define identity, and were thus categorized as *undefined*. Note that we only looked at the explicitly stated theoretical framing of identity in each paper. We did not classify them based on their use of language around identity outside of their theoretical framework or their assumptions about identity inherent in their research design. Doing so would have resulted in the majority of papers being placed in the combination category, since, as previously explained, there remains a great deal of inconsistency in the use of identity in science education research papers.

Table 11.1 provides exemplary quotes culled from the articles we reviewed. The first is an example of possession approach in which identity is conceptualized as

Table 11.1 Quotes exemplifying possession, negotiation, and combination perspectives on identity

Possession	Identity theory is a microsociological theory that focuses on the self as a collection of identities, each of which is based on a particular role (Stryker 1968). . . . The various role identities that a person holds exist in a hierarchy of salience, which refers to how much importance we place on each role. (Buck et al. 2006)
Negotiation	Identity is a human-made construct and is constantly re-created through interactions that play decisive roles in determining the dynamics. It is best viewed as a process and a work in progress (Goldston and Kyzer 2009).
Combination	The concept of 'identity' in this study should not give associations to a fixed, 'true' self behind whatever the student is engaged in. 'Identity' is a multifaceted concept; some aspects are more stable than others, some aspects more 'true' than others. (Knain 2005)

something that resides in the individual as a collection of relatively static identities that coexist and are made salient through the individual's emphasis on one identity in particular. In this conceptualization, there is little space for the impact of others in one's identities, as even which identity is emphasized at any given moment is conceived as an individual's choice. Studies using role identities often, but not always, tended towards a possession perspective of identity, as discussed earlier. Often such papers presented identity categories, such as science identity or ethnic identity, and discussed how participants brought these identities into different contexts, and how these identities influenced how the participants engaged with their social world. Other key indicators of a possession perspective on identity included the use of terms such as identity development and identity formation, which portrayed identity as a personal characteristic that is shaped over time in a cumulative process rather than being re/constructed in interaction.

The second quote exemplifies the instability of identity as it is negotiated in interactions with others. Here, the authors acknowledge the continuous and never-ending process of negotiating one's identity at every interaction. Many articles in science education used quotes from identity theories that conceptualized identity as a process and as dynamic at some level (changing over time or over contexts), but very few remained attached to this view throughout their papers; more often, authors combined a negotiated approach to identity with a possessed approach used somewhere else in their paper. Some authors even combined both approaches within their theoretical framework, with no clear articulation for how these two opposing views could cohere. As shown in Table 11.1, articles that adopted a negotiation approach to identity often described identity with terms such as (re)constructed, (re)created, performed, unstable, in flux, and so forth. They emphasized dynamism and wrote about identity in-the-moment, rather than identity-over-time. Many such articles took a discursive approach to identity, that is, they viewed discourse as being a key aspect of identity construction, insofar as discourse plays a very important role in our interactions with others and the material world around us.

The third quote exemplifies how the two views, possession and negotiation, were combined in the reviewed papers. In some cases, an explanation of how identity can be possessed by the individual, but also be under negotiation, is attempted. This was often done, as shown in Table 11.1, by considering identity to consist of layers, which have the ability to change to varying degrees. However, in the majority of combination papers, the two views were expressed in separate parts of the theoretical framework, but were never addressed together, resulting in an inconsistent framework.

As seen in Fig. 11.1, using the possession vs. negotiation framework to classify the theoretical conceptualizations of identity employed in the articles reviewed revealed an interesting relationship: studies addressing issues of equity were significantly more likely to adopt a negotiation perspective to identity, while studies not focused on equity were slightly more likely to take a possession perspective. Also, studies that did not focus on equity were more likely to not define identity at all.

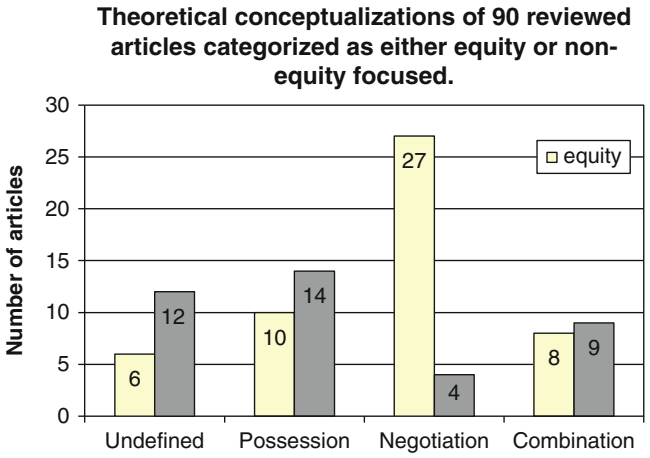

Fig. 11.1 Classification of the reviewed articles as adopting either a possession or a negotiation approach to identity

This tendency of articles focused on equity issues to use a negotiation approach can be explained by the inherent socio-critical perspective that is foundational to a view of identity as negotiated in interactions. Many of the theoretical foundations used to define identity as negotiated are socio-critical, such as Bourdieu's and Medina's work, and lend themselves quite easily to discussions of oppression, marginalization and equity. By placing identity as a product of intersubjectivities and social relations, rather than as something residing within the individual, the negotiation perspective allows for a discussion of the structural constraints and affordances on one's agency, as well as of how particular ways of being can become privileged in society (and in the school, classroom, etc.), necessarily engendering marginalization and oppression. The role of others in defining who we are and our own roles in doing the same for others is emphasized when identity is viewed as constructed and negotiated in interactions; likewise, our roles as individuals in perpetuating inequalities, marginalization and oppression are also more easily uncovered within the negotiation approach to identity.

A relatively stable identity, as is the case with conceptualizations of identity as something we possess, even if still exposed to changes of some sort, places the burden on the individual as the source of its positionality in society; that is, there is little one can do to change who one is, inasmuch as a core identity is persistent and underlies everything else we might aspire to become. The social forces that come into play in defining one's identity during (past, present and future) interactions is a difficult issue to access through the possession approach to identity. Even the way in which the researcher sees the participants and assigns to them a particular core identity, which is unchanging or at least very difficult to change, already presupposes that the very act of analyzing them as research subjects does not bear on who they are, that is, on their identities. Social relations are not only disregarded in some possession conceptualizations, which are more psychological in nature, but

these relations are also missing from an evaluation of the research and the impact it may have on the participants.

This, however, is not the case with all conceptualizations of identity as possessed. In fact, in many of the reviewed articles, the authors switched back and forth from possessed to negotiated views of identity (see Fig. 11.1). The theoretical sections of some papers discussed identity in several different ways, following various different authors, some of which presented quite incompatible views of identity. A common problem we found in the literature was that authors attempted to place themselves in a middle ground position between possession and negotiation. Many of these articles, in attempting to take the middle ground, ended up with unaddressed contradictions in their theoretical framework. For instance, in many such cases the reader was left wondering which aspects of identity change and which are stable, and how this change might occur and, perhaps most importantly, how the researchers have access to these changes.

Whether or not one agrees with the proposed possession vs. negotiation framework, it is important to always frame identity coherently and consistently use this framing throughout the entire research process. Many of the reviewed studies presented problems in the language used for writing about identity in the findings and discussion sections of the paper. Most notably, many authors who theoretically framed identity as negotiated in interaction would, at times, slip into everyday ways of speaking about identity that were in contradiction with their theoretical stance. While careful consideration of all choices of language around identity when proposing a fully negotiated perspective is the most obvious solution to this problem, one method we have found useful in our own work is to write of identification as a verb, rather than identity as a noun. For example, "Here we see her identifying with science," as opposed to, "Here we see her science identity." This use of language automatically supports a negotiated perspective, presenting identity in its "active form as a performance, that is, to identify, and therefore suggesting a process, rather than being a static noun" (Brandt 2008, p. 706).

Another common problem found in the literature occurred when identity was theoretically conceptualized as negotiated during interactions, but the analytical framework used approached the data within a possession perspective. This was the case, for example, when the data were not analyzed within an interactive framework, and the insights derived from the data analysis failed to discuss identity in interactional and negotiated terms, rather implying that the participant possessed this or that identity. If a negotiation framework is used, it is essential that the methodology is also interactional and does not assume that identities be observed in one situation and applied to another.

Maintaining coherence when using identity as theoretical and analytical tools in research is a challenge not only because identity is such a complex construct, conceptualized so differently by several authors, but also because our own language constrains our possibilities of operationalizing identity in everyday language. Identity is a multifaceted construct that does not easily render itself to simplified definition. Its historicity, temporality, contextualization and dialectical relation between the social and the individual, the past and the present, the self and others,

continually perplexes the researcher attempting to get a grasp on the nature of identity. However tenuous our grasp on identity might be, we must re-evaluate our use of it in our work, from the initial design of our research to the final paper, and from the first to the last sentence in our writing, to make sure that we at least have been consistent in committing to a particular way of conceptualizing and operationalizing identity, thus avoiding methodological incoherence and the consequent jeopardization of the quality of our research.

Achieving Consistency: Matching Different Approaches to Identity with Appropriate Research Designs

As discussed earlier, oftentimes the reviewed articles presented inconsistencies in their theoretical definitions of identity and in their use of this construct throughout the paper, either in terms of analytical approaches to the data or in terms of the language used to refer to identity. We do not want to prescribe any particular conceptualization of identity as the most appropriate for sociocultural research in science education; however, we do think that each approach yields different research outcomes, and therefore may be better suited for particular research designs.

Conceptualizations that view identity as possessed tend to focus on the individual rather than society, and often conceive of identity as existing within a broader timeframe that encompasses the life experiences of the individual.[4] Because of its tendency to emphasize the existence of a core identity and/or various role identities residing within the individual, conceptualizations of identity as possessed may render themselves more easily to investigate adults' identity related issues, as these individuals have already reached a certain level of maturity that allows speaking of a stabilized core identity. Likewise, adults have likely already accumulated a range of life experiences that provide them with the possibilities to develop multiple role identities. This possibility is supported by the results of the literature review, which showed that 50 % of authors who took a possessed perspective were interested in teacher (or student-teacher) identities, compared to only 23 % of authors who took a negotiated perspective on identity. The focus on a stable version of self (i.e., core and/or role identities) also constrains the possibilities for investigating identity-in-the-making; indeed, a possession view of identity usually emphasizes already established identities and how these affect the individual's interactions or participation in societal activities, or how events occurring outside of the data have contributed to the development of this identity. Thus, the possession approach to conceptualizing identity renders itself more easily to research interested on how identity shapes interaction and participation in particular situations. This interest should therefore

[4] This is not to say that negotiated framings of identity cannot support broader timeframes. However, the accompanying methodology must be carefully considered. For example, we have found the concept of trajectories of identification (Wortham 2006) particularly useful in broadening identity timeframes within a coherent negotiated framework.

be reflected in the type of research questions formulated, as well as the overall research design (methods of data collection, analytical framework, and terminology used).

In keeping with the possession view, appropriate methodologies would focus on the individual and their life experiences. For example, interviews may be analyzed by looking for instances when the participant's identity(ies) becomes apparent through discourse, thus helping the researcher understand the participant's underlying identity. Alternatively, the nature of the participant's identity may have already been predetermined through another method (e.g., survey or participant observation) and then the researcher can analyze the interview data to understand how the identity affects the participant's interactions and participation in society, or how the predetermined identity was developed. Indeed, most reviewed studies that consistently used a possession approach to conceptualize identity relied on descriptive data and analyzed it in ways very similar to those suggested here. For example, one of the three articles that measured identity with a survey, followed up with interviews in order to understand how these identities were developed during prior experiences with science teaching. This article theoretically framed identity from the possession perspective and therefore we considered it to be consistent throughout.

As a consequence of focusing on pre-established identities, studies that rely on a possession view of identity may approach social change from an *a posteriori* stance. That is, the social influences on one's identity formation are elaborated in terms of systemic issues that, if and when changed, might lead to changes in people's identity and consequently in their way of interacting and participating in society. However, there is little room for individual's identity to change given the structure in place, so that any changes would have to be initiated elsewhere. The individual is thus rendered powerless in face of structural constraints and there seems to be little opportunities for identity to change as well. That is, the already existing identity(ies) of the individual looms in the background even when new role identities are brought into play; differently put, any change to an individual's identity is constrained by its core or stable features, which underlie one's ways of interacting and participating in society. Thus, individual and social change become more difficult to account for within this way of conceptualizing identity.

In contrast, within a negotiation approach to identity, the focus may be on how interactions and different forms of participation shape identity; therefore, social change is conceptualized as something that each individual might achieve through agency, despite or because of structural constraints. The process of disidentification (Medina 2006) is an example of this form of change, which originates from individuals and reaches out to society. On the other hand, the role of structure in identity construction is also exposed within this way of conceptualizing identity, particularly when considering the importance of the other in identity negotiation during interactions and the availability of socially fixated stereotypical identities, which can be considered structural constraints on one's identity construction.

Indeed, due to its focus on identity construction during interactions, conceptualizing identity as negotiated requires a focus on the social aspects of interactions and participation. Consequently, data collection that takes place in situ, in naturalistic

(Guba and Lincoln 2005) environments that expose the socially negotiated nature of identification is preferred. The analytical level may be micro, focusing on short timeframes that capture the richness of details of interpersonal interactions, but with an overall macro perspective that guides the interpretation of data within a broader sociocultural framework. In contrast to the example of possession methodology previously described, the same interview data could be analyzed to observe instances of identity construction, thus providing insights into how social structures are reproduced, or even produced through instances of agency. Oftentimes, this framework is also critical and political in nature, which more easily leads to discussion of marginalization, oppression and underrepresentation issues. For example, one reviewed article that theoretically framed identity as fully negotiated, used videos of classroom activities to explore how students from a minority population either took up, resisted, or transformed the positions made available by their inner-city institution, and the latter led to shifts in the structure of the institution.

The danger here for the researcher would be to assign identities to individuals without connecting these to the interactional clues that allow the analyst to access the negotiation that is taking place in relation to one's identity construction in the moment. As discussed earlier, many articles that used a negotiated approach to identity fell prey to inconsistency in their methodological choices by analyzing data in search of established and relatively stable identity(ies) that justified one's actions. A clearer distinction between what is one's identity and what are socially established stereotypical identity models or roles one may occupy or aspire to, may also help avoiding further confusion when analyzing data and writing from a negotiated approach to identity.

Finally, we would like to stress that, although we have discussed methodologies that we believe to be most clearly linked to either the possessed or the negotiated perspective on identity, we are not arguing that these are the only options for research taking either one of these perspectives. Instead, we are arguing that research taking any methodological approach needs to explicitly address how it coheres with the theoretical framing of identity, and care should be taken to ascertain that the language used is consistent with the theoretical standpoint chosen.

Next Steps

Although we maintain that trustworthy and valuable research can be conducted using any coherent theory of identity, our own science education research is situated within a negotiation approach. The majority of the reviewed science education articles that addressed equity issues espoused theoretical frameworks that conceived of identity, at least in part, as negotiated. We suggest that this trend in science education research is because the negotiation perspective lends itself well to understanding the process of marginalization, providing the much needed link between the individual and the social world, allowing researchers to observe how social interactions result in patterns of production and reproduction. Freeing identity from its boundaries of historicity and powerlessness in face of structural constraints

provides the opportunity to envision possibilities for social change that are both more immediate and attainable, in terms of ground-up strategies that rely mostly on individuals as social agents. Each and every small instance in our daily interactions are contexts for reproduction and maintenance of status quo—but they are also contexts for social change.

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Chapter 12
A Socio-culturally Sensitive Science Curriculum: What Does It Have to Do with Our Bodies?

Giuliano Reis

Learning Science on a Saturday

> [According to the Arab educational philosopher Avicenna[1]] the sights and sounds of things around us are transformed into pictures in the mind. [This so called] sensory knowledge is basic to all the acquired knowledge of the sciences. The learner then reflects upon the pictures of what is perceived in a thoughtful way in order to reconstruct his intellectual knowledge. (Solomon 2003, p. 252)

One thing I still remember: it was a sunny Saturday with a clear sky. Back home, most of catechism classes in the Catholic Church take place on Saturdays. That day my teacher asked the whole class to describe anything in the environment that we remembered seeing on our way to the church. The underlying idea behind his question was to get us talking about the signs of life that are all around us, right in our faces, and how easily we take them for granted. I used to live little more than half a mile away (0.9 km) from the parish and had to walk about 15 min to get to class. I had no reason for not having an answer; and yet, I couldn't remember one single element of my surroundings that had grabbed my attention that day besides the obvious road, the usual cars and their noise. I tried to imagine the shape of at least one of the trees I passed by in the park I had crossed only a few moments before or even the color of the flowers I was sure were blossoming at that time of the year. More sadly, neither the memory of an animal (like a dog or bird) nor an insect (perhaps a bee or fly) and their habitual (and familiar) morning awakening sounds were able to pop up in my head. It felt as if I were in automatic pilot all the way to the church that morning. I learned a valuable lesson that day, one that I shall later

[1] See Al-Naqib (1993).

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return to in order to emphasize the importance of our embodied experiences to the learning of science.

In this chapter I focus on the possibility and significance of adopting a sociocultural approach to science education curricula. While this statement may ring as old news to some, the fact is that the broader science education community (i.e., researchers, teachers, students, and parents) continues to strive to find more engaging, authentic and meaningful ways to understand and increase interest in science at the various levels of formal and informal education (Dionne et al. 2013). In addition, any attempt to increase the overall public understanding of science—and hence their scientific literacy—is desirable (e.g., Lima et al. 2010). According to William Sandoval (2005): "In contemporary democratic societies, lay citizens need to understand the nature of scientific knowledge and practice in order to participate effectively in policy decisions and to interpret the meaning of new scientific claims for their lives" (p. 637).

(Un)Learning Science at School

Historically, scientists have been focused on trying to force order onto the messiness of nature by creating experimental conditions in laboratories (Sismondo 2010). For instance, medical research is highly controlled so that it can be reproduced and validated by different teams of specialists all over the planet—though this is not always the case (e.g., Caulfield 2007). This apparently objective way of *doing* science in sterile environments ended up inevitably being transferred to the *teaching* of science at schools. As a result, it is not uncommon to find classrooms where science is approached from a stereotypical standpoint; that is, populated with representations of (mostly male) scientists whose work is impartial, constantly accurate, largely inaccessible to the lay citizen and unmediated by society at large—naïve and undesirable views that do not reflect the reality of the nature of the scientific practice (van Eijck and Roth 2008). In sum, typical science instruction presents science as a collection of incontrovertible facts that describe the world (Sormunen and Saari 2006). Such an approach effectively blocks students from identifying themselves with the works of science. More so: it gets in the way of recognizing their own bodies as production sites of (a personalized/customized type of) scientific knowledge. In addition, it neglects the fact that "social and cultural factors surrounding discovery may be at least as important as the justification of knowledge" (Cobern 1995, p. 287). Put differently, school science has been sanitized (Weinstein and Broda 2009) to the point where it now symbolizes a type of knowledge that is seemingly from nowhere and:

> There is enormous power in the view from nowhere which effectively becomes the omnipotent view to everywhere. (…) In so many ways, we exist in an educational era of nowhere and everywhere. Our curriculum documents seem to arrive bearing little trace of their geographical, material or cultural origins. Mass produced textbooks and worksheets now increasingly shape teaching practices. And dominant policies refer to children never being

> left behind, although who these children are, or what they are being left behind from, is far from clear. Indeed, the word education itself has an unnerving generalness, devoiced from a sense of temporality and context. It is almost as though we have to keep pinching ourselves to remember that we live and work in unique contexts–that our practices comprise particular schools and classrooms full of unique learners. (Alsop and Fawcett 2010, p. 1033)

Such an approach to science knowledge in which students are blocked from seeing a role for themselves in the construction of science helps us also to understand the corrosion of public interest in science. A more socio-culturally relevant (sensitive) science curriculum and pedagogy appeal as a promising solution to the separation of science and society conundrum. Succinctly, such curriculum and pedagogy endorse the view that knowledge is socially constructed and context dependent (Wertsch 1991) and represent approaches to learning and teaching that utilizes socio-cultural referents to construct knowledge, skills and attitudes that empower people intellectually, socially, emotionally and politically (Tippins et al. 2002).

In the present chapter, I revisit the notion that it is through one's own body that a socio-cultural context becomes utterly possible. After all, if "to live is to know" (Maturana and Varela 1992, p. 174) then one lives—and conversely feels alive[2]—first and utmost through his body. From a sociocultural (and cultural-historical) perspective, "the body, which necessarily occupies a spatial-temporal location, both fixes the subject [socially and] historically, breaking down its universalist assumptions of individuality, pure rationality and self-interest" (Peters 2004, p. 15); that is, one's body both constitutes the meaning and marks the limit of one's relations with others (Sartre 1966). Ultimately, I hope to stimulate the discussion about the necessity (and possibility) of a phenomenological-like approach to science curriculum to (re)make contact with our bodies and (re)discover the uniqueness of perceiving the world *through* them (Nagataki and Hirose 2007).

The next section is dedicated to the role of teacher training programs in preparing future science teacher adequately to adopt a stronger social-cultural agenda in their science teachings.

The Unnaturalness of Teacher Training Programs

How much of the science that teachers teach (and students learn) is anchored in a socio-cultural standpoint? How much responsibility do teachers have for this situation? Part of the job of science teachers is "to help [students] to appreciate what

[2] According to Solomon (2003, p. 254): "there is something reciprocal about our perceptions and the environment. For the ancient sense of touch this is easy to understand. When our hands touch a cold surface they are chilled at the same time as the surface is warmed (cf. Abram, *The Spell of Sensuous* 1997). Put differently, "the 'environment' and the 'learner' emerge together in the process of cognition, although this is a false dichotomy: *context* is not a separate background for any particular system such as an individual actor" (Fenwick 2003, p. 130).

scientists had in mind in talking about a topic in a certain way and to persuade them of the value and reasonableness of that way" (Sutton 1996, p. 147). This puts teachers in an influential (leading) position within the context of their science classrooms. On the other hand, teachers themselves often do not get a chance to do science in their own educational experiences—they have rarely, if ever, conducted scientific inquiries for which they had significant responsibility for procedures and conclusions (Windschitl 2003). This has unfortunate consequences.

Clare Kosnik and Clive Beck (2009) followed 22 graduates into their first 3 years of teaching in Toronto and surrounding areas. After several interviews with participants and classroom observations, they identified seven elements in pre-service teachers training programs that needed to be prioritized in teacher education: (i) program planning, (ii) pupil assessment, (iii) classroom organization and community, (iv) inclusive education, (v) subject content and pedagogy, (vi) professional identity, and (vii) a vision for teaching. Of particular interest for my argument here is *subject content*. According to the authors:

> In recent decades, teacher education has tended to focus on theory and "general method," to the relative neglect of content and pedagogy specific to subjects such as literacy, math, and science. For example, it is not uncommon to find elementary pre-service programs with just 40-hour course on literacy teaching and even less on math or science. In our view, it is time to return to giving priority to subject specific knowledge in pre-service preparation. Although teacher educators were right to reject the earlier assumption (still widespread in the public at large) that subject knowledge is *all* one needs in order to teach well, we have often gone to far to the other extreme. Much of the school day is spent teaching specific subjects and accordingly teachers must be prepared for this work. (p. 105)

The researchers assert that a further difficulty in ensuring that new teachers are sufficiently equipped to enter the profession is that "they may not have explored the links between subjects as required for teaching across the curriculum. And they may not have given much attention to connections to everyday life" (p. 114). This is to say that although science teachers need to learn both content and pedagogy specific to science, they also need to know how to integrate them into the learners' everyday life practices and to other areas across the curriculum. However, those current curriculum documents *from nowhere* are unlikely to be of any assistance to teachers in solving this issue. Much like science and its curriculum have been antisepticised, it appears that teacher education programs have been stripped down of their essential bonds with the reality of the *extramural* educational system with consequences that go beyond the prospective reported unpreparedness of novice teachers:

> It is a matter of no small consequence that the only people who have lived sustainably on the planet for any length of time could not read, or, like the Amish, do not make a fetish of reading. My point is simply that education is no guarantee of decency, prudence, or wisdom. More of the same kind of education will only compound our problems. This is not an argument for ignorance, but rather a statement that the worth of education must now be measured against the standards of decency and human survival—the issues now looming so large before us in the decade of the 1990s and beyond. It is not education that will save us, but education of a certain kind. (…) The plain fact is that the planet does not need more "successful" people. But it does desperately need more peacemakers, healers, restorers, storytellers, and lovers of every shape and form. (Orr 2004, pp. 8 and 12)

As a consequence, it is now common sense that higher education in general and teacher education more specifically are often times regarded—anecdotally or not—as a waste of time and money if compared against the benefits of practical experience[3] alone (e.g., Huang and Moon 2009). For instance, on his message about the passion for learning—and teaching of—biology, Edward Wilson (2006) states: "knowledge accompanied by pleasurable emotion stays with us" (p. 127). He goes on to draw on descriptions of some of his favorite university professors to illustrate such passion, which he claims not to be able to define in words "because it exists in a multiplicity of unpredictable forms." He continues, "Allan Archer was not a teacher, nor did he want to be, which made him all the better one" (p. 128). Does Wilson's position imply that the ability to teach proficiently is lost when one officially graduates as a teacher? Are the expectations, concerns, and pressures put onto teachers unbearable to the point where they end up succumbing to the political and technical traps inherent to the job? Once a teacher, does one's ability to think creatively and critically vanish? I had similar questions in mind when I decided to ask a group of 72 student teachers enrolled in my senior biology class to comment on Wilson's quote. I was curious to know to what degree they would eventually expose their personal perspectives on the soundness of the teacher education program in the development of their identity as teachers. Below are two of the most interesting responses posted on the class blog[4]:

> Not everyone that is a teacher is able to teach. I have had "bad" teachers, as well as great and mediocre teachers. However, I think some of the best teachers I have had are the ones that never went to school for a bachelor of education. They are the people who are in love with their field of expertise, the people who live and breathe what they do. They are able to communicate their expertise without even knowing they are "teaching." This is why I strongly believe that not all people who want to teach end up being great teachers. (BG)

> Teaching is innate; subject is learned. If you can teach you can teach anything regardless if you are passionate about the subject matter. Passion for the profession of teaching holds higher regard than that of subject content. (FK)

In these two posts, both students downplay the significance of the teacher education program to the improvement of their future career. In addition, they seem to indicate that teachers are born, not made. Even though those two posts represent an infinitesimal fraction of the totality of respondents (less than three percent), I believe they characterize a type of reasoning that insists on lingering amongst future teachers and amounts to an increasingly widespread sense that science in schools—whether elementary, secondary or post-secondary—could be doing much better. In other words, those posts point to the fact that there are still deficiencies associated with the today's science teaching. Of course, it would be naïve to presume that one day our classrooms will be completely free of any pedagogical dilemmas, but I do believe that science curriculum documents can support pre- and in-service teachers in promoting a more engaging, authentic and meaningful type of science education

[3] For an interesting discussion on the different meanings the word practice can take when associated with learning teaching, please see Lambert (2010).

[4] Initials of students' names were used in order to preserve their anonymity.

by promoting the use of students' bodies as means to learn science. That could be one of many possible *right* kinds of education that Orr refers to in his quote. Having struggled in my own career with the very same issues around making science more appealing to my students, next I share my thoughts and experiences in hopes of strengthening the echoes of those optimistic voices that too believe teaching science has a purpose worth realizing (e.g., Wang 2004).

Embodied (Sensory) Learning

> The relations between things or aspects of things having always our body as their vehicle, the whole of nature is the setting of our own life, or our interlocutor in a sort of dialogue. (Merleau-Ponty 1962/2005, p. 373)

Tina Kazan (2005) points that

> Teachers who *do* acknowledge embodiment—most notably the people present and the felt sense of the moment (ranging from awkwardness to passionate discoveries)—benefit from a more complex understanding of their students and their classroom. Both teachers and students can enjoy more opportunities for learning when the corporeal text of the classroom is recognized. (p. 381)

Indeed, Kazan's line of thought is aligned with that of Joan Solomon (2003) who claims: "it is through our senses that we perceive and also, in a participatory way, become a part of our surroundings" (p. 254). Hence, teaching and learning (in science) are embodied actions (e.g., Vick and Martinez 2011). One needs not to look far in order to corroborate such a model of knowing. For example, as part of my own training as a researcher I once interviewed my oldest daughter (AJ) about the occurrence of night and day[5]:

GR: So the question is very simple. Could you explain [to] me why we have day and why we have night?
AJ: Okay. Because we need day to play and we need night to sleep and then if we don't have day we don't have light and we can bump [into] something.

In this situation, AJ explains the existence of day and night in terms of her own personal—as a human child—needs, like playing, sleeping, and not getting hurt. Right at the outset, I formulate what I expect AJ to provide; that is, an explanation rather than just any response ("could you explain [to] me"). AJ's use of the conjunctive "because" deems her response appropriate for the context of our conversation/interview given that it frames her answer as a reason: "because we need day to play and we need night to sleep." Aside from the collaborative production aspect of the conversation/interview, AJ justifies the naturalness of day and night based on her direct (sensory) experience *in* the world—the distinction between the two is simultaneously visual and tactile. She *sees* the light, which in turn allows her to *see* the obstacles (e.g., furniture in the house, car on the street, fence in the backyard, etc.).

[5] This transcript originally appeared in Roth (2008).

Additionally, she does not want to "bump" into things, which she only knows by having encountered such situations before—i.e., she has most likely collided with objects herself and got hurt. (As her dad I can assure you that this is the case…) Even when AJ makes reference to playing and resting ("sleep"), she is indeed talking about embodied actions: her body feels tired (after playing) and needs a break. In the end, AJ demonstrates possessing a private (personal or egocentric) understanding of what purpose day and night serve. Ultimately, and from a Gibsonian eco-psychological point of view (Ingold 1992), AJ perceives and learns about her environment in relation to what it affords her to do (i.e., play, rest, and get hurt).

In the context of school-related settings, I have seen similar references to an embodied modality of learning experiences. Take Larry for instance: he is an award-winning public teacher with over 20 years of experience who has designed and implemented an outdoor environmental education program in a west coast province of Canada. The following excerpt was taken from an interview he gave to a local TV channel[6]:

> Larry: We really made a big effort to design a program that kind of addresses all the different learning modalities, all the different ways we learn, and the different ways we think about things, the different intelligences that students have when they plug themselves to a task. So, it's very much hands-on, very tactile. The kids actually are lowering down the Secchi disk over the side [of a dock] and pulling the rope back up. So, they feel the salt water in their hands and they can smell all the specimens up close and they can hear things that are happening around them. So, we try to get them really involved.

Larry's account of what students' do as part of the program contains the reasons why the activities are "very much hands-on." (In the original broadcast, the TV featured images of some of the "very tactile" actions students perform to address "all the different ways" in which they learn.) Larry's description is very powerful in that it carries the learning benefits of this type of direct physical perception of the world: the feeling of "the saltwater in [students'] hands," the smelling of the living creatures up close and the hearing of what is "happening around." No book or blackboard can provide students with these specific sensations, which only reinforces the relevance of the same activities for the engagement of students. It is a statement that first-hand contact with nature has a unique and remarkable influence on participants. In this situation, the language of science is learned through the feeling (experience) of handling a Secchi disk.

Direct experience is a recurrent theme in the talk of those involved with Larry's initiative—and Nina is but another case. When I asked her about the planning stages of the outdoor program, she replied[7]:

> Larry and I had this idea about how we were going to do it [the program] in the Lagoon and I was very, you know, I think what my approach [was] to start with the head, you know, and think about it and do a very academic kind of style of education, which kind of surprises me looking back because I've evolved myself and that's not the general approach. My general approach is having them fall in love with the world that, with [the program] I was a little

[6] This transcript originally appeared in Reis and Roth (2007).

[7] This transcript originally appeared in Reis and Roth (2010).

> stiff because maybe it was a new environment and I thought [of] all this great opportunities to do marine investigations and blah, blah, blah, scientific experiments, blah, blah, blah. And then we invited the teachers to come and then sit with us and give us their ideas and when it came to the wetland part one of the teachers said: "Well, this is all very fun and good, but this is the place where more quiet reflection might be required, this is a place where children can really actually sit and listen and look and watch and reflect on their experience." And my instant reaction was "Bahamong! What a bunch of crap! We only have these kids for a certain number of hours. What is this reflection business? What is this, you know, sitting down and touching-and-feeling?" (…) And that's really changed my way of looking at environmental education. Include all parts, include the body, include the heart, include the soul, include the mind…

Nina's answer builds on the early stages of the program, when she teamed up with Larry to devise it. At the time, she had "this idea about how [Larry and her] were going to do it." In recalling the past, Nina articulates that she had an approach that was "very academic" or "with the head," which translated in her perceiving "great opportunities to do marine investigations (…) and scientific experiments." Ever since that episode, Nina's approach to learning has changed: she now wants students to "fall in love with the world." In this manner, she differentiates what she considers to be an academic/rational/scientific/stiff perspective on learning from one that is nonacademic/emotional/nonscientific. Still according to Nina, this transformation came about when other teachers eventually became involved in the design of the program and one of them suggested that the wetlands station should require more "quiet reflection," a place where children could "sit and listen and look and watch and reflect on their experience." "A bunch of crap" as Nina recalls thinking of it. She seemed overtly concerned with the time constraints that made the "reflection business" sound like an unaffordable luxury—"we only have these kids for a certain number of hours." Currently, this station is Nina's favorite ("the heart of the program"), one that she is "totally in love with" and that has made it possible to see education differently (Fig. 12.1). Nina concludes: she is not exclusively about the "head" anymore, but for the inclusion of "all parts"—body, heart, soul, and mind. Her original and strict pedagogical cognitive standpoint ("to start with the head") has changed to include the notion that there are embodied (and emotional) ways of knowing about/in science (and the environment[8]) that are equally important. In this way, Nina constructs herself as someone whose pedagogy has critically "evolved" as the result of experience and reflection to a more comprehensive (affective) way of teaching science.

Larry and Nina's outdoors activities are typically accompanied by a school-based component that has placed 4,000-dollar aquaria in the hallway of more than a dozen local public schools. The underpinning goal in this case is to foster learning about science and the environment through giving students the dual responsibility of caring for the animals that are in the aquaria and mentoring younger students to do the same. Together, both programs (outdoors and indoors) have been delivered to

[8] Science and environmental education are considered to be intertwined, which would provide teachers with great flexibility to decide what parts of the prescribed curriculum are covered and how to go about it.

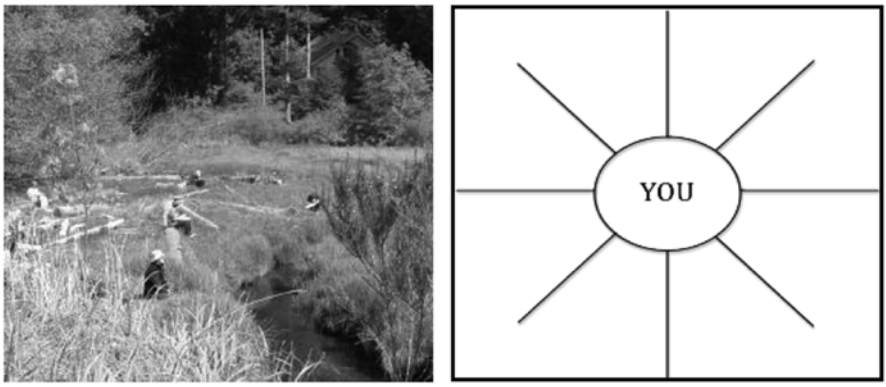

Fig. 12.1 *Left*: Students at the wetlands station, quietly appreciating the natural environment around them. *Right*: Sound map worksheet similar to the one students use to situate themselves within the natural environment using their perception of the various sounds present

thousands of students over the last decade. According to its designer, Carolina, the aquaria create a big increase in awareness because students are left taking care of living creatures "they take very personal sort of emotional responsibility for it. And we think that's really important in creating that link to learning that makes fit a part of their real world, you know?" The "real world" that Carolina talks about is intertwined with the very embodied nature of her curriculum and pedagogy, which includes encouraging students' use of senses as a teaching strategy to gather information about the variety of animals brought to school (Fig. 12.2).

In other words, teaching and learning are the direct result of the interactions of students and teachers with the surrounding environment. These interactions encompass experiences that affect—and are affected by—the way learning and instruction happen. Here, my observations once more run counter to the general lack of consideration for the embodied way people learn (O'Loughlin 1998). Likewise, they reaffirm that the process of perception is also a process of action, where we perceive the world as (and because) we act in it. The inscription of teaching and learning experiences within the physical boundaries of our bodies (and minds) can be so meaningfully lived that it is unlikely to be forgotten, particularly if generated by (safe) levels of discomfort. This aspect of an education in/for science is the focal point of the next section.

Discomfort as Means to Experience Learning

> Hardness and softness, roughness and smoothness, moonlight and sunlight, present themselves in our recollection (…) as certain kinds of symbiosis, certain ways the outside has of invading us and certain ways we have of meeting this invasion. (Merleau-Ponty 1962/2005, p. 370)

Fig. 12.2 *Clockwise*: (a) Example of saltwater aquarium located in the hall of an elementary public school. (b) A fourth grader closely inspects one of the many sea animals brought to class in buckets prior to their placement in the aquarium. (c) Students manipulate a sea worm. (d) Students' body orientation to a tray containing sea creatures and that is placed on a desk

It is at least provocative to celebrate the uneasiness discomfort provokes as a teaching and learning strategy. In times where war, natural disasters, and global diseases abound, one can easily think of many different contexts to which the word would apply. One may feel discomfort—to say the least—in being sick, or deprived from water or sheltering. In the realm of education, one may feel distressed, anxious, embarrassed or worried over a science test (Reis et al. 2013). However, I use the word discomfort here as an invitation to readers to step back momentarily from the familiar coziness of what they believe to know to experience learning differently, more body-consciously. It is an incitation for people to step out of their comfortable textbook modus operandi into the real world (Watson 2003). In a way, it is similar to athletes who become fully conscious of their body only during pain or illness. Otherwise, "the body 'disappears' from daily awareness in a phenomenological sense until it is brought to our attention through its malfunctions" (Leder 1990, as cited in Tarr and Thomas 2011, p. 145). (Note that it is out of the scope of this chapter to discuss what would be acceptable limits of discomfort/disgust and the potential negative effects on students' learning once they are reached [Holstermann et al. 2012].)

Ellen Langer (1997) identifies seven myths or false attitudes that are embedded in the educational system and that inhibit students' growth and interest in learning (Fisher 2000). They are the following: (a) many in education believe that the basics

should be so well learned that they become second nature, (b) educators think that paying attention means staying focused on one thing, (c) conventional education buys into the idea of *work (learn) now and play later*, (d) rote memorization is important in education, (e) memory is essential to living in the world, (f) teachers often act as if intelligence consists of knowing facts, and (g) many teachers believe there are right and wrong answers. Although I believe that all the points raised are remarkably accurate and indispensable in any conversation around (science) teacher education reform, I would like to ponder for a moment on the first one in particular.

One apparent advantage of drilling in the basics is that it leads naturally to automaticity—or *learning without thinking*. This skill is greatly desirable by those learning a new language. Who wouldn't like to speak different languages and be able to switch from one to the other without any trouble? (I know I would…) If like Jay Lemke (1990) one believes that "learning science means learning to *talk* science" (p. 1) and that "we learn this language [of science] in much the same way we learn any other," then it is not difficult to see how the idea of *automaticity* can be a hot commodity for some in science education. People want to be "able to communicate their expertise without even knowing they are 'teaching,'" as one of my student teachers claimed above (BG); "an 'innate' capacity," is what the other said (FK). On the other hand, automaticity does not equate to *fluency*. Put differently, the solidification of students' understandings of certain aspects of science—whether they are basic concepts or general processes—does not warrant their automatic appeal to students or their application to different contexts (e.g., life outside school). The quality of learning is not only dependent of specific situations (Lave and Wenger 1991), but it is also improved significantly when it is reflected upon using the learner's metacognitive abilities (e.g., Yilmaz-Tüzün and Topcu 2010). This is to say that people learn best when they are cognizant of their own learning conditions.

In the scenario of a safe and caring learning environment, discomfort is but one pedagogical strategy available to improve knowing and learning in science education. It can be transformed into a powerful learning tool that prompts learners to become aware of what they do in the classroom. For instance, I once co-taught a 1-h lesson with a biology college teacher as part of a workshop on how to use case studies in science. After hours writing the case and deciding on what exactly each one of us would say and do during the activity, I had an off-script moment at the last minute: I decided to ask people in our audience (mostly high school students) to act out their parts in the case. We were the last group to present that day and I thought that making the lesson different for the students (and ourselves) would help build the right atmosphere to boost engagement (unlike those teachers who fit Langer's last myth). My colleague literally went ballistic and was less than pleased with the modification I suggested. She reasoned that my move could put students on the spot and make them uncomfortable. It did not take her long to realize that the whole point of my initiative was indeed to make our audience feel a little awkward and therefore mindful of the lesson. In the end, students seemed more responsive to the whole activity than they were in at least the previous ones.

A similar episode happened in China where I was visiting Mike, a good friend of mine, who was teaching science at a Sino-Canadian private high school in an eastern province. My friend and I teamed up—as we had done many times before when he was in Canada—to teach about how the process of polymerization of the protein casein in cow milk can be used to produce natural plastic (basically rustic cheese). The experiment required the addition of vinegar to milk in order to obtain curds—our raw fragments of natural plastic—that were then molded into anything we wanted. While an enthusiastic group of students, my friend was taken aback by their overall reaction to the touch of the curds as well as the strong smell of acetic acid that diffused throughout the whole classroom. Students were initially reluctant to touch the curds (although they were at room temperature) and also covered their noses with tissue paper (Fig. 12.3, right). Ultimately, they were communicating their discomfort to what they were doing through their bodies. The way my friend and I interpreted the situation was that those students had not been exposed to that type of hands-on session before.

Surprisingly, the buzz caused by the activity did not prevent the students to enjoy it so much that they started molding the curds into various objects (Fig. 12.3, left). As I have stressed elsewhere (Reis et al. 2013), discomfort—in the form of anxiety, for example—should be regarded as an important typical part of the authentic learning processes in science education. Individuals who participate in science activities (e.g., science fairs or hands-on lessons) are *en route* of understanding a topic. Put differently, they are in transition from a circumstance where they do not know to another where something has been learned—and this learning process is in itself *uncertain* and *unpredictable,* just two other sources of discomfort. (Note that

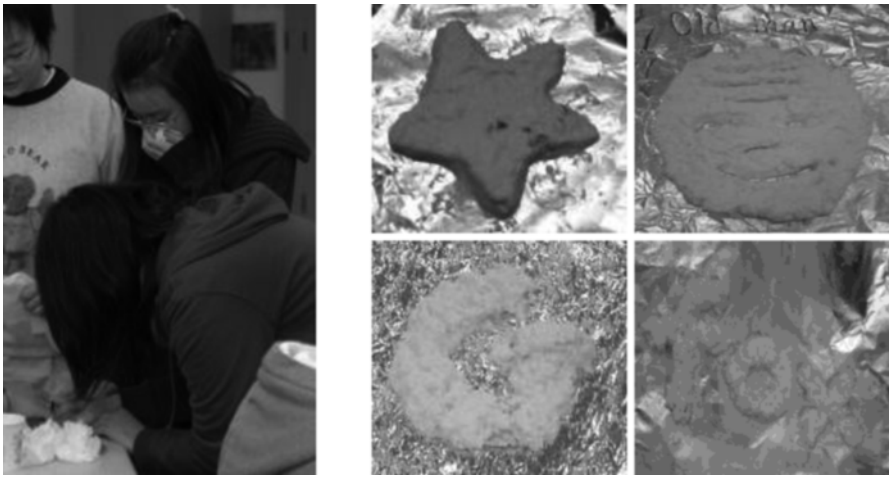

Fig. 12.3 *Left*: Chinese High School students working on a hands-on science activity. Note the student covering her nose with tissue paper in response to the smell of vinegar in the classroom. *Right*: The different shapes students molded milk curds into. (*Clockwise*: star; face of an old man with forehead wrinkles; letter "g" (in a reference to my first name initial); and the word "fox")

the notion of the Zone of Proximal Development applies well in these situations [Wells 2003].) Unfortunately, there have been few opportunities and incentives given to teachers and their students—especially in the science curriculum—to celebrate and encourage this kind of open-mindedness. (The next section deals with possible practical alternatives to this issue.)

Finally, it is probably correct to assume that students participated in the activity because of the classroom context; that is, the always-present assumption that they are supposed to do what the teacher says and the expectation that an evaluation was most likely to follow. On that note, there were students who goofed around and seemed uninterested in participating in the activity. Nevertheless, they were clearly exposed to an activity that they were unfamiliar with. Although it is uncertain whether or not this exposure was enough to change their perceptions of science—and by any accounts this was not the main reason why we did it—students nonetheless had an experience that they probably would not have outside the context of our lesson.

Body-Less Science Curriculum

As it has been emphasized, our bodies are paramount to the success of learning and knowing in science education. So, it comes as no surprise that body metaphors are common in education. Metaphors permeate all discourse and are fundamental to human thought (Aubusson et al. 2006). In the context of education, the use of metaphors has been extensively investigated for its role in instruction (e.g., Cameron 2003). This is not without reason: If we accept that "the essence of metaphors as the means of understanding and experiencing one kind of thing in terms of another" (Lakoff and Johnson 1980, p. 5), then metaphors are generally useful in introducing new and abstract concepts to others (Munby and Russell 1990)—and science is no exception (e.g., Semino 2008). Furthermore, metaphors are the product of a linguistic choice: "when we signify things through one metaphor rather than another, we are constructing our reality one way rather than another" (Fairclough 2006, p. 195). Consequently, we become "responsible for the metaphors we choose to privilege and we need to be critically (and self-critically) responsive to the effects of their deployment" (Doll and Gough 2002, p. 74). Take the following excerpt from an interview with Monique, another Canadian public educator:

> I remember I got a ride from somebody who was just getting into environmental education. I don't know why this just came to me, but he was concerned because he didn't have a strong science background. I don't have a science background either. I've just taught myself, but I think it comes from [the] love of the teaching and love of the environment and if you have those two things that's more important than all the science knowledge. It's the kids, your audience—whether they're kids or adults—they pick upon it and if you don't care about it and you don't exude that in how you talk and how you interact with the environment when they're out there with you the message isn't gonna get through.

In the context of her interview, Monique draws on a body metaphor to account for her lack of a science background: "if you don't exude [your love for teaching

and for the environment] in how you talk and how you interact with the environment… the message isn't gonna get through." To exude is to make apparent and exhibit it abundantly. It is a physical phenomenon, one that can be picked upon (e.g., seen and heard) and of a nature unlike that of "all the science knowledge." According to Monique, our (body) actions and attitudes resonate more strongly with an audience than any knowledge one might have accumulated.

Monique's story (and metaphor) is but an additional practical evidence that it would be counterproductive—to say the least—to deny the advantages of promoting a phenomenological orientation to curriculum in/for science education. However, as suggested before, this appears to be the case in schools and faculties of education. Much like the type of science knowledge that is seemingly from nowhere, some current science curriculum documents are body-less in the sense that they neglect to elevate the sensory experiences of students to a place of higher importance in school learning and knowing. To illustrate this last point, I now look at the Ontario science curricula.

The Science Curricula in Ontario

The Ontario science curricula were revised in 2007 (elementary curriculum [grades K-8]) and 2008 (secondary curriculum [grades 9–12]). The review process was strongly informed by 32 recommendations put forward by the report *Shaping our schools, Shaping our future* (OME 2007b), a document elaborated as part of the so called Ontario Ministry of Education's environmental education initiative. Therefore, these curriculum documents (OME 2007a, 2008a, b) exemplify a contemporary type of curricula as they incorporate environmental education (EE) more explicitly in the science classroom. More so: the fact that they tap into the value of experiential learning to science education—also commonly associated with EE—broadens their scope beyond the Canadian context. Altogether, they typify suitable objects for my analysis.

The expression *hands-on* readily invokes the image of an embodied action, where hands are used to touch and feel what one does. It encompasses the notion of active participation as opposed to a more passive involvement. In a quick search for the term in the Ontario elementary science curriculum, there are few instances where it appears in reference to pedagogy of the body and the learning and knowing processes of students. These occasions are listed below (my emphasis):

> Using a variety of instructional, assessment, and evaluation strategies, teachers provide numerous **hands-on** opportunities for students to develop and refine their inquiry skills, problem-solving skills, critical and creative thinking skills, and communication skills, while discovering fundamental concepts through investigation, exploration, observation, and experimentation. (OME 2007a, p. 8 [Role and responsibilities in the science and technology curriculum])

> Typically, students demonstrate diversity in the ways they learn best. It is important, therefore, that students have opportunities to learn in a variety of ways—individually, coopera-

> tively, independently, with teacher direction, through **hands-on** experiences, and through examples followed by practice. (OME 2007a, p. 28 [Instructional approaches])

> Research and successful classroom practice have shown that an inquiry approach, with emphasis on learning through concrete, **hands-on** experiences, best enables students to develop the conceptual foundation they need. Instructional approaches. (…) Equipment, tools, and materials are necessary for supporting the effective learning of science and technology by all students. These concrete learning tools invite students to explore and investigate abstract scientific and technological ideas in rich, varied, concrete, and **hands-on** ways. (OME 2007a, p. 29 [Instructional approaches])

> Students apply the knowledge and skills they acquire in their study of data management in mathematics to gather, interpret, and describe data collected through **hands-on** investigations of relationships in science and technology. (OME 2007a, p. 40 [Literacy and numeracy in the science and numeracy program])

> Energy is a commonly used term that describes an important part of daily life. Since the concept of energy can be abstract, it is important to approach this topic in a practical, **hands-on** manner. (OME 2007a, p. 50 [Grade 1, Understanding matter and energy])

In all the excerpts above, there is reference to the value of involving students in concrete—however undefined—activities that would enable them to experience learning in a sensory and meaningful fashion. In those examples, the term *hands-on* is used to denote one of the roles and responsibilities of teachers as being to adopt those types of activities as an instructional approach to science more generally and literacy and numeracy more specifically. At the same time, it is peculiar that only once the word is included as part of a strand; that is, out of the eight grades covered in the prescribed curriculum (each containing four different strands[9]) in one strand alone is the expression "hands-on" identified with a particular topic (i.e., energy). I also searched for occurrences of the word *sense* and some of its variations—like *senses* and *sensory*. My findings are compiled in Table 12.1.

In this case, the words searched are used in/for more precise contexts. For example, in 2.2 and 3.4 students are expected to use their senses to investigate the characteristics of objects and structures. Likewise, they are supposed to make their own senses the object of their learning in both 2.3 and 2.5. Here, and contrary to the general and somewhat unstructured previous use of the expression "hands-on," the word sense is employed in a manner that facilitates teachers and students making sense of the overall expectations in the curriculum. For instance, it should not be a difficult task to ask a child to use her five senses to explore (investigate) the characteristics of objects or come to understand—through the use of analogies and metaphors related to her body—that plants and other animals have sense organs similar to her own. It is true that the simplicity and specificity of these examples could be an attribute of the word *sense* itself and not the context in which it is used—i.e., that of the overall expectations of a strand in grade one—but either way it is undeniably practical. Remarkably, the word *sensory* was never found in my search of the elementary curriculum. Neither were any of those words found in any grades other than grade one!

[9]The four strands common to all eight grades in the elementary science curriculum are: (i) understanding life systems, (ii) understanding structures and mechanisms, (iii) understanding matter and energy, and understanding earth and space systems. All the science curriculum documents can be obtained at the Ontario Ministry of Education website: http://www.edu.gov.on.ca/eng/curriculum/

Table 12.1 Results from my search for places in the Ontario science elementary curriculum (OME 2007a) where the word *sense* and its variations are employed (my emphasis)

Elementary Science Curriculum (Grade 1)	
Overall expectation	Description
2. Developing investigation and communication skills	2.2. Investigate characteristics of various objects and structures, using their **senses**
	2.3. Investigate and compare the physical characteristics of a variety of plants and animals, including humans (e.g., some plants produce flowers and some do not; most plants have roots; some animals have two legs, while others have four; all animals have **sense** organs)
	2.5. Investigate characteristics of parts of the human body, including the five **sense** organs, and explain how those characteristics help humans meet their needs and explore the world around them (e.g., our hands have fingers and a thumb that are flexible to allow us to pick up food; our legs have the two biggest bones in our bodies, to carry us around to do the things we need to do; our tongue has bumps that help us to determine if our food is too hot, too cold, or tastes bad; our ears are shaped like cones to catch sounds that warn us that danger is near and to hear the beautiful sounds of nature), using a variety of methods and resources (e.g., observation of themselves and other animals, outdoor experiences, prior knowledge, personal experience, diagrams and/or charts)
3. Understanding basic concepts	3.4. Describe the function/purpose of the observable characteristics (e.g., texture, height, shape, colour) of various objects and structures, using information gathered through their **senses** (e.g., sandpaper is rough to help take the rough edges off wood; a traffic light is tall so it can be easily seen; a stop sign is the same shape and colour in many countries around the world to make it easily recognizable)

What about the secondary science curriculum? Surprisingly, my findings were not so different than the ones for the elementary document. First, my search for the term *hands-on* resulted in excerpts that were analogous to the ones presented in the previous section with only the wording varying slightly. Numerically, there are three more instances where the word emerges in the secondary curriculum when compared with the elementary text. One applies to the same circumstances described before—that is, to describe one of the roles and responsibilities of teachers as being to adopt hands-on activities as an effective instructional approach to science:

> Teachers of science can support their students' learning by maintaining links with community-based organizations to ensure that students have access to **hands-on** experiences that will reinforce the knowledge and skills they have gained in school. (OME 2008a, p. 42; 2008b, p. 44 [Cooperative education and other forms of experiential learning])

In the other two occasions the word is employed to depict the applied courses in grades 9 and 10 and to define scientific inquiry, respectively:

> Applied courses [in grades 9 and 10] focus on the essential concepts of a subject, and develop students' knowledge and skills through practical applications and concrete examples. Familiar situations are used to illustrate ideas, and students are given more opportunities to experience **hands-on** applications of the concepts and theories they study. (OME 2008a, p. 11 [Overview of the program])

> Scientific inquiry: The cognitive strategy and **hands-on** procedures through which students develop knowledge and understanding of scientific ideas and of the various methods scientists use to study the natural world. (OME 2008a, p. 101 [Glossary])

As for the word *sense* and its variations, my search returned zero results this time! Altogether, this simple analysis of the Ontario science curricula reveals a tendency to use the term *hands-on* in less specified conditions that the word *sense* and to relegate the privilege of a pedagogy of the body only to one strand in grade one. At the end of the day, any ideas and actions to overcome this state of abandonment of our bodies in the curriculum has to be initiated by the teacher. In the next section, I provide another personal narrative about how I have dealt with the matter in my classes.

Poetry, Bodies and Science Education

> One touch of Nature makes the whole world kin. (William Shakespeare)

As someone who is involved in the training of future teachers, I have been bothered with the lack of attention paid to or bodies in science education. As a result, I constantly challenge my students—whether elementary or secondary—to think about feasible ways of incorporating their direct experiences into their teaching.[10] One way is through poetry (Howard 2010).

Inspired by the International Science Poetry Competition[11] (Eastwell 2007), I decided to ask my students to write a five senses poetry. This makes use of as many senses as possible and is meant to help students focus on a sensory expression of the world around them. It also demonstrates that science is not all about objectivity and can be experienced (and therefore learned) in creative ways—in much the same way as environmental education (Tsevreni 2011).

A while time ago, I had a chance to take my students to an outdoor centre for a half-day field trip—the perfect occasion to challenge them once more to think about their bodies in/for learning science. (While this activity could be conducted in the classroom, I opted for doing it at the centre). Once we arrived at the site, I quickly revised what the five senses were. Next, I gave students a small index card and a pencil and asked them to write down five incomplete sentences: *I hear*…, *I smell*…, *I taste*…, *I feel*…, and *I see*…. Then, I invited them to go out in the woods in complete silence for 3 min and complete the sentences based on what they were able to hear, smell, taste, feel, and see (Fig. 12.4). Once back to the cabin, I explained that they had a few days to use their complete sentences to create a poem and post it on our class blog. The poem could rhyme or not, it could be made solely of the five

[10] One of the ways of incorporating one's experiences into the science classroom is through storytelling (e.g., Gargiulo 2007). However, this topic is better left to be discussed another time.

[11] More information on the International Science Poetry Competition can be found at http://www.scienceeducationreview.com/poetcomp.html

Fig. 12.4 Students walk silently in the woods in order to complete the five senses poem activity. Note the student on the *left* of the picture is writing on her index card

sentences they had written down or not. In the end, all I wanted was to let my students free to chose the format of their poem, specially knowing that it was their first time writing one. The activity was a success (based on the feedback I received from the students) and even those who initially was reluctant to participate did very well. Two examples of poems posted on the blog are shown below:

The crisp cool air surrounds me
While the warmth of the sun's my cocoon.
The snow kissed trees are a vision in white
While the birds play a lovely tune.
The crunch of the plants dried up for the season
Sings a song that I'm finally home. (FA)

Standing here, far away from the madding crowd of the city,
I can see the amazing greatness of the sky,
I can hear the cheerful singing of little birds,
I can smell the pleasant fragrance of the woods, and
I can feel the wind gently kissing on my face.
I can taste the nature. (MA)

A brief discussion on the viability and usefulness of the assignment for teaching high school biology followed. I could see by the reactions and body language of some students that they were not entirely comfortable with the idea of creating a poem. I clearly stated that I wanted to know their thoughts as well as safely and momentarily push them out of their comfort zones to make them conscious of their bodies during the silent walk in the natural environment (see previous section on discomfort). As they debriefed about their impressions, they proposed different ways of introducing the activity without ever questioning their validity.

This activity (like the one in the wetlands) is but one approach to the curriculum that brings about the importance of the body as the primary site for *being, doing and knowing in the world*. In the poems, the woods are not inert environment, but alive and moving, existing in unison with—and responding to—our own actions. This is also an example of what is being called *slow pedagogy of place*, which

> Highlights the importance of the body in an education with various environments—as those bodies are lived in and over times in natural spaces. A slow pedagogy, or ecopedagogy, allows us to pause or dwell in spaces for more than a fleeting moment and, therefore, encourages us to attach and receive meaning from that place. (…) There needs to be a shift in emphasis from focusing primarily on the "learning mind" to re-engaging the active, perceiving, and sensuous corporeality of the body with other bodies (human and more-than-human) in making-meaning in, about, and for the various environments and places in which those bodies interact and relate to nature. [A] pedagogical turn to an "ecocentric intercoporeality" (Payne and Wattchow 2009, p. 16).

In the classroom context, a close look at the poems usually leads to discussions around how the hearing of our troops is being affected by all the noise of tanks, helicopters, and explosions during the war; it serves as a segue into a lesson on sense organs and how people who are blind, for instance, rely on the other four senses to locate themselves in any environment[12]; or to explain the curious case of cell phone applications that emit sound frequencies only heard by people a certain (young) age. Examples of how an experiential (sensory) activity as simple as a sensory-based poetry activity can be tied to different strands in the provincial science curriculum documents and to the everyday life of learners abound in the media—i.e., newspapers, radio, websites, and books. One important way that teachers can promote this approach to science knowing and learning by initiating occasions that encourage those kinds of encounters (interactions) of the bodies with socio-culturally relevant (natural) environments (Diamond 2008).

Concluding (and Cautionary) Thoughts

> Eliza felt ridiculous. She'd gotten so wrapped up in thinking of science as some complicated endeavor that she had overlooked an important lesson: Simplicity was the key to science. Eliza walked across the street to her neighborhood florist, bought a bouquet of daisies, buried her nose in them, and breathed deep. It had been a while since Eliza had bothered to do that. (Dutton 2011, p. 179)

The ideas put forward here are based on the conviction that any socio-culturally sensitive science curriculum and approach must embrace pedagogy of the body as means to mediate knowing and learning in science education. This phenomenological approach implies that whenever people interact with their physical or socio-cultural environments it is primarily through their bodies that such interactions are situated

[12] A notable example is blind men who can echolocate (e.g., Thaler et al. 2010).

(contextualized[13]). From this perspective, knowing and learning consists in the organization of sensations impinging upon our (always) receptive human bodies. On the other hand, scientific knowledge cannot be learnt from direct sensory experience alone and learners come to personal understandings of scientific ideas that already exist in the culture from their interactions with teachers, textbooks and peers (Leach and Scott 2003). The salvage of an embodied approach to science pedagogy and curriculum should not be a reduction of experiential learning to our sensory organs, but an expansion to include other types of (critical) engagement with the world. In the words of Kari Sormunen and Heikki Saari (2006):

> Personal knowledge construction in science is not so easy, since most of the knowledge is very abstract. Abstract scientific knowledge cannot be constructed or learnt by the student on his own. Students need the teacher's help in knowledge construction. (…) Science learning is both personal and socio-cultural. In the sociocultural framework, students' understanding is not seen as shaped only through adaptive encounters with the physical world. On the contrary, understanding develops through interaction between people in relation to that world. (p. 27)

Moreover, if "the human mode of existence implies a 'being-in-the-world' where the objects of consciousness and consciousnesses themselves cannot exist without each other" (Peters 2004, p. 17), then there are additional types of experiences (interactions) that must be accounted for in the learning of science:

> Human learning occurs when individuals, as whole persons (cognitive, physical, emotional and spiritual), are consciously aware of a situation and respond, or try to respond, meaningfully to what they experience and then seek to reproduce or transform it and integrate the outcomes into their own biographies. In this instance, biography is the totality of our experience, which is an integrated combination of the cognitive, emotive and physical, and learning is the process through which individuals grow and develop. (Jarvis et al. 2003, p. 67)

But one needs to be cautious. According to Tara Fenwick (2003), the rush to privilege experience can overlook certain difficulties inherent to the type of experiential learning discussed here and could mislead one to believe that explanatory frameworks are irrelevant. These difficulties would stem partly from a hidden body-mind split typical to existing discourse around embodied learning. Fenwick (2003) eloquently outlined four specific problems: First, the assumption that experience (body) is concrete and distinct from reflection (mind)—i.e., *doing* and *thinking* are not separate phenomena. (In this context, the term experiential learning is in itself controversial since learning is always experiential unless experience is confined exclusively to sensual or kinesthetic activities.) Second, the continuing emphasis on mentalist reflection, which centres learning in a rational knowledge-making mind that rises above the messy bodily dynamics to organize experience—a somewhat narrow-minded conception of learning that disregard the mutually determined and continuous nature of reflection and knowledge. Third, the disciplinary mechanisms of language, measurement, and knowledge legitimation impinged by the current

[13] The concept of *egomorphism* (Milton 2005) illustrates well the use of our bodies as a reference to situate (contextualize) our own experiences in the world.

education system and that denies the political, social and cultural spheres of experience thus distorting people's experiences in the process of assessing, dividing, and forcing them into manageable categories. Fourth, occurs when people and their knowledges, which are not considered to be worth enhancing,[14] are excluded.

> An embodied curriculum especially in relation to aesthetics and the arts begins from an understanding of a philosophy of the body not conceived in opposition to a philosophy of mind but rather as the basis for a materialistic social ontology that heals the Platonic and Cartesian dualisms of Western philosophy. A new philosophy of the body as an educational project will draw lessons from phenomenology and especially the work of Merleau-Ponty. It will also draw on Nietzsche's notion of embodied rationality, a rationality that does not attempt to abstract from our moods, our situatedness, our cultural belongings, our embodied selves and physicality, our animality that together help to compromise our linguistic and cultural identities. (Peters 2004, p. 25)

I did not intend this chapter to be a treatise on philosophy of the body—let alone a prescription of how one should teach science. Likewise, I do not advocate that all science teaching should be of the sort described here—although I continue to maintain that the use of our senses in order to learn about science is justified by making it more memorable and fun (Solomon 2003). In addition, I realize that most of my examples drew upon observations of events and interviews with people associated with environmental education. Nonetheless, if one believes that "all education is environmental education" (Orr 1992, p. 90) then science can be taught through lessons geared toward the natural and social environment. By moving beyond the traditional focus of the science curriculum at both schools and faculties of education I pledge (like many others before me [e.g., Doerr 2004]) that students and teachers be offered—and conversely create or find—opportunities to learn and teach science in socio-cultural settings that privilege their bodies and their essential unity with mind. If indeed curriculum change is primarily a matter of changing the conditions of teacher learning (Darling-Hammond and Sykes 1999)—and teachers learn much in the same way that students do (Haury and Rillero 1994)—then the role of teachers might be conceived as *system disturbers* (Fenwick 2003), where they challenge dominant categories used to recognize experience and judge what is considered relevant learning. Like John Dewey, I too believe that if education is to be effective, its goal is not only to prepare students for life, but also to engage students wholly in life at the present moment (Fletcher 2009). I truly hope that there will be more inspiring situations in science classrooms where students can engage more wholly in science. And the body can serve as a critique of educational traditionalism and inertia and come to serve as a basis for a reformed curriculum in science. After all, "it is only at the scale of our direct, sensory interactions with the land around us that we can appropriately notice and respond to the immediate needs of the living world" (Abram 1997, p. 268). This is what I believe I started to realize that Saturday at the church.

[14] The value attributed to certain kinds of knowledge has been discussed elsewhere (Reis and Ng-A-Fook 2010).

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Chapter 13
Youth Media Productions: Deconstructing "Difference" or Reifying Norms?

Donna DeGennaro and Tiffany L. Brown

Situating the Rise of Youth Media Productions

The educational engagement of underrepresented youth in the production of various forms of media is on the rise. Community organizations interested in educating youth draw on the fact that youth are increasingly participating in the creation of media content such as web pages, blogs, wikis, videos, and radio. Examples of organizations that employ these efforts include Youth Speaks, Listen UP!, Youth Radio, and BraveNew Voices, to name a few. Many of the efforts involve using technological tools to document, assess, analyze, and deconstruct the worlds in which they live (Goodman 2003). Further, the organizations aim to assist youth in using the media creations to envision new possible futures and generate new forms of social action (Chavez and Soep 2005). According to Elisabeth Chavez and Vivian Soep (2005) one of the inherent strengths in youth driven media production is that "it starts where the young people are" (p. 410). This is similar to the pedagogical perspectives put forth by Jeffrey Duncan-Andrade and Ernest Morrell (2005) on the importance of "drawing on the sociocultural practices of students" (p. 284) and "building upon what is already present in students" (p. 290).

There are perhaps two significant overarching phenomena that bind and underlie these initiatives. One relates to providing youth with a venue and a means by which they can (re)image their culture (Riecken et al. 2006) or the self and community (Hull and James 2007). The focus on (re)imagining self, community, and culture is grounded in the historical trail of racialized representations of marginalized groups. The intent of historical representations of minorities was to exasperate difference,

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privilege Western culture, and ostensibly westernize the "other." Conversely, youth created media efforts seek to forefront difference in order to appreciate and celebrate cultural difference. This effort aligns with a growing body of literature that aims to privilege difference not as difference per se, but as an acceptance and awareness of the simultaneous existence of valued cultural ways of being and knowing (Appiah 2006). Media, whose etymological meaning is "intermediary" or "measure" (as in content, milieu, or culture), has the potential to not only communicate an individual or collective identity, but also to mediate the actor's consciousness of those representations (Davis and Gandy 1999). In using media to document one's environment, youth have the opportunity to deconstruct the political, social, and institutional structures that intersect and yield an oppressive and racialized view of "other." Subsequently, these same tools that are used to create the representations can be used to analyze and (re)present/(re)construct that view.

The falling costs for media related equipment is the second significant event that has made participation in youth created media more viable. Until recently, the access to technological tools that support these efforts was cost prohibitive. Tools such as internal cameras on computers and Flipcams allow the user to take and download HD (High Definition) quality video respectively to a personal computer. Even through high end editing software remains extremely costly, personal computers come with preinstalled basic editing photo and video software that yields semi-professional products. The affordability and availability of tools has resulted in the increased propensity of researchers, educators, and youth organizations to put technological tools in the hands of youth in order to assist them in seeing and telling their (hi)stories and envisioning and enacting alternate social futures from their own vantage points. With school curriculum putting increased emphasis on standardized testing, out of school youth media environments provide a unique space for youth to engage in learning activities that facilitate youth development and result in products that have a sociocultural impact (Chavez and Soep 2005).

While these efforts are laudable and essential, audiences will not necessarily accurately interpret the authors' projected messages in the ensuing (re)presentations. In other words, simply creating alternative images of the self, community, and culture does not ensure the transformation of deeply embedded perceptions of cultural groups. It is widely accepted that the ideological representations that the producer intends to portray are not passively consumed (Gramsci 1971). Instead, audience interpretations of media productions are socially and culturally mediated according to one's context (Hall 1973). As youth create new images of themselves and their worlds, the audiences who view them will interpret the productions through their own historical lenses. This calls to question whether the engagement of youth in media productions in fact helps to deconstruct difference and foster valued alternative ways of being or assist in reifying the historical collective consciousness related to the notion of underrepresented cultures.

In this paper we explore the rise of youth media productions as an educational activity to (re)present the notions and implications of imagining "other." We draw on theories of cultural studies and critical pedagogy to examine the historical and evolving media representations of as well as the learning approaches aimed at

reshaping that history. The historical gaze assists us in understanding the potential for why this youth media production trend materialized. Further, the historical understanding of the racializations of minorities is a way to surface the socially constructed and unconscious ways of seeing "other." We apply the aforementioned theories to our analysis of the pedagogical ways of engaging youth in media productions and to inquire as how they either liberate or reinforce norms. We then elaborate on the value of using media as an educational tool to elicit more authentic interpretations of media creations, which and which potentially yield new ways of seeing/imaging "other."

Historical Representations of Underrepresented Groups

Early Images

Historically, Westerns and colonials have represented marginalized groups as deficit, damaged and in need of being "fixed." Namely, these groups are presented as lacking the social and cultural capital to become successfully integrated into a particular worldview (Dodson 1999). The implication is that these groups ought to be shown the way and mainstreamed into the "dominant society." Furthermore, the ways in which people are illustrated and treated often gives way to situating normative beliefs. For example, in the early 1900s the Australian government approved legislation that authorized the forcible extraction of Aboriginal youth from their homes. Children were confined and educated in rudimentary English and taught manners of the Caucasian society (Sydney Morning Herald 2002). What is more, these youth were taken from their communities in order to educate them in western ways and breed them with Whites to ultimately eliminate the Aboriginal race. Similarly, in the late 1800s and early 1900s, Native Americans in the United States were taken to reform schools in order to civilize this purportedly unsophisticated culture (Dilworth-Anderson et al. 1993). During the birth of the US, Blacks were also being socially constructed as deviant and in need of reform. Namely Black youth, according to educational officials, needed to be "instruct[ed] [] mentally and morally" (Bacon 1856, p. 7) and their education should advance their "knowledge and refinement" in order to obtain a "useful occupation with persons" (Bacon 1856, p. 3). Remnants of this continued as colonizers and slave owners created laws that prohibited Blacks from educational, social and political rights, which contributed to their social alienation. The treatment and representation of these groups has not only historically been inscrutable, but relentlessly has set foundations of racial identities that promote these people as inferior and less able or intelligent.

This racialization has further been perpetuated through culturally produced and socialized mainstream media. Beginning with drawings and photographs from as early as the 1800s and 1900s pictorial depictions conveyed distorted identities of Africans (Qureshi 2004). Further, Westerners' photographs of non-Westerners

included the omission of elders and large families and instead focused on the idealization of youth (Lutz and Collins 1993). In the United States, perhaps the most notable form of Western representation was side-by-side images of Native youth in "savage" settings and clothing juxtaposed with these same youth in colonial attire. Such images have attempted to capture depictions of this group adapting to colonial domination (Churchill 1995). However, these groups were not adapting, instead they were involuntarily forced into subservient roles and positions and were unable to circumvent the hierarchical political and institutional dominance of colonials. Artists also depicted slaves as either simplistic people enjoying their constricted lives or as lazy and defiant workers who were neglecting their imposed responsibilities. Such out of context representations denied, or at the very least made difficult, the full participation of marginalized groups in how they are seen.

These few examples illustrate photographic strategies that heighten the manipulated interpretation of the viewer (Lutz and Collins 1993). For example, non-Westerns were coached to look directly into the camera, which from a photographic perspective, suggest a more vulnerable position. From a photographic perspective looking directly into the eyes of the audience takes away the power of the subject, which in turn evokes an equal or lesser than impression for the viewer. The manipulation of the subjects' gaze or position dictates the audience's authority on the subject. The images imply subjugated and disempowered existences. Largely produced by those in dominant cultural positions of the time, the semiotic inscriptions of subject purposefully included depersonalization (Goffman 1969), distance (Hall 1966) and dehumanization. The intention of the Westerner and/or colonizer is to enhance perceptions of the difference between "them" and "us" as well as foreground the superiority of one's own culture (Schroeder 1998). Groups often created oppositional identities (Ogbu 2004) as a resistance to this subjugation as they were unable to circumvent the hierarchical political and institutional dominance of colonials. It was not until the "mid-1920s that Blacks began to demand changes in their representation in the White minds or social image" (Ogbu 2004, p. 13).

Modern Media

Despite marginalized groups' struggle for social justice related to such images, early radio and film continued to put forth similar representations that reinforced stereotypes. Perhaps the most famous of these is the situational comedy Amos n Andy. This sitcom, which transitioned from a radio to a TV show, is seen as the foundation for racially stereotyping the African American Community in modern media. Created by White men, the stories were noted as a benign beginning of racial mockery (Lawrence 1987). Researchers also report that, compared to Whites, Blacks and Latinos are more likely to be spotlighted in crime stories and portrayed as suspects or the perpetrators on television (Bjornstrom et al. 2010). These portrayals add to the stereotypes surrounding the criminalization of minority groups and the negative perceptions of them. Moreover, additional research suggests that these kinds of messages influence attitudes that play out in social contexts (Mastro et al.

2009). A collective and shared history of experiencing other as mediated by such portrayals has contributed to unconscious development of cultural beliefs toward non-Whites (Delgado and Stefancic 2001).

More recently, members of marginalized groups have taken positions of authority in the creation and production of various forms of mass media. For example, movies such as "Boyz in the Hood" and "Menace II Society," produced by African American directors, characterize the plights and possibilities of African American experiences from the perspective of these groups. The directors use real and figurative symbolism to characterize the social structures within the "hood" and the institutional structures that impede movement out of or transformation of it (Massood 1996). The symbolic references "define the hood as a ghetto by using surveillance from above and outside to take agency away from people in the community" (Diawara 1993, p. 22). In music, Public Enemy's *Fight the Power,* an influential Hip-Hop song, called on African Americans to mobilize against racism. This song spurred a fight against racist oppression by authorities and corporations in the United States. It encouraged education and awareness of oppression as a key strategy in fighting against the structures that limit the mobility of Black people.

These more recent forms of media seek to position underrepresented groups as authority in bringing to light the complex interplay between oppression and possibility as a cultural production of the African American experience. Even though more recent efforts have engendered a shift in perceptions, they continue to compete with the negative light that mass media shines on minorities. *Fight the Power* and *Boyz in the Hood* use forms of dress, accents, vernacular, and lyrics to symbolize identity of African American culture and/or oppression. Yet in news, sitcoms, movie titles, and other media, Blacks, Hispanics, and Latinos continue to be pictured as ominous, dangerous, and different. Viewers take in images of these groups engaged in crime, drug use, gang violence, and other forms of anti-social behavior (Balkaran 1999). Thus, the symbols might inadvertently contribute to, and unconsciously strengthen, the already imagined perceptions put forth by dominant group-created historical representations of minorities. Specifically, an oppositional reading of this might contain the notion that the characters in these movies are a group of angry Black youth. These images evoke the historical representations in the audiences that view the film through a decontextualized lens. To further compound the issue of stereotypical images is the disproportionately low media representations of particular ethnic groups, specifically Latinos and Asians. Both the absence of groups and the negative portrayals of people of color combine to increase the popular consciousness of the historical remnants of such historically created hegemonic images.

Engaging Marginalized Youth in Media (Re)construction

Researchers and educators have generated various initiatives associated with these same media as a means of assisting youth in (re)imaging these seemingly unwavering, racialized individual and collective identities. These efforts, however, do not end

with the goal of creating media; they also include pedagogical strategies to assist youth in uncovering the social and political structures that play a role in their current situations as well as how they are perceived. This critical approach works to raise consciousness of the youth in the more often than not oppressed position. Further, the approach seeks to empower youth to use their context to construct his/her image of self and surroundings. Finally, the attempts intend to implore the youth to think of alternative realities and to potentially take initiative to participate in social action.

We examine two examples of youth created media engagements that aspire to connect youth with their identities, communities, and/or worlds. While there are numerous initiatives with this mission, we choose to examine one example from the following within the following mediums: digital storytelling and broadcast radio. For each of these media, we begin by applying critical pedagogy (Freire 1970) to the description and analyze the design of engagements with these mediums. Critical pedagogy asserts that education should always be a process by which we critically unearth structures that impede or facilitate social justice. This critical examination comes as a result of making connections between power, injustice, and societal norms. We employ this to consider how the structures facilitate or liberate youth agency in the educational process. Next we draw on cultural media studies to analyze the socially and culturally situated meaning and whether in what way the meaning might either liberate difference or reinforce norms. Specifically, we employ Stuart Hall (1973) encoding/decoding analytical model to consider possible dual meaning in created and interpreted in media texts. We assert the intentions of the author (encoder) and then consider an audience interpretation (decoder). We take the audience to be from outside the urban context in order to infer what oppositional reading might occur. We know from cultural studies that "meaning making is indivisibly linked to social structure" (Fiske 1987, p. 254), thus we juxtapose contexts of underrepresented encoding with outsider decoding to imagine possible interpretations of youth-created media. In the closing section, we use the same literature to put forth future considerations in helping to bring about more negotiated meanings of youth media productions, in order to better ensure possible emergence of difference as an equally valued way of being in the world.

Digital Stories

Many organizations engage youth in various forms digital storytelling. These projects range from scripted programs to less structured programs. More scripted programs, such as SCMW (Silk City Media Workshop), take youth through a step by step process of creating a story and converting it to a storyboard, learning a video editing software, and then gathering pictures and music to use for their final productions (DeGennaro 2008). DUSTY (Digital Underground StoryTelling Youth), a more open-ended program, affords youth opportunities to create various forms of digital narratives. These narratives might include verbal performances, photos, storyboards, musical compositions, animations, or digital stories. The organizers see that these

forms of expression provide a means by which youth can exemplify and personify the self in direct relation to their peers and community members (Hull and James 2007).

These programs are similar in that their underlying aim is to bridge the digital divide and foster literacy skills, both old and new (Lankshear and Knobel 2006). The articulated goals of providing skills that are situated in the dominant cultural perspective are a reflection the historical view of the dominant class' oppression of "other." Digital divide initiatives, although well-intentioned, have often been designed contrary to a Freire (1970) view of participation. The phenomenon is largely attributed to the division between minority and White access to digital technologies, such as the Internet and computers. The digital divide is arguably a resultant effect of the historically unequal opportunities and treatment of minorities. Technology learning initiatives such as SCMW and DUSTY emerged in an effort to bridge that divide. The notion, however, of "catching up" or "providing skills" is reflective of a banking model of learning and is similar to attempting to mainstream these marginalized groups into society. More often than not, outside experts come in to model "appropriate" uses that will translate into marketable skills. Without bringing the participants into the conversation about what they know and how they analyze the role of tools within their own world and future, efforts of empowerment become futile and potentially reproduce the very divisions that they attempt to close. According to Paulo Freire (1970), "Attempting to liberate the oppressed without their reflective participation in the act of liberation is to treat them as objects that must be saved from a burning building" (p. 10).

The ways in which SCMW and DUSTY implement their programs are through the services of undergraduate mentors and expert teachers. In SCMW, mentors and teachers create a formal structure of learning that reflects a school-like feeling. These mentors stand in the front of the room and students sit in rows facing the teacher. Their role is to impart skills of literacy, both reading and technology based. In DUSTY, mentors participate in a service learning class. Undergraduates are asked to reflect on their experience as they move in and out of the after school space. They often work side by side with expert teachers. Researchers describe that these adults are careful to be knowledgeable of boundaries between the university and urban community worlds. Both organizations aim to afford youth the opportunity to be in positions of authority to not only create the digital products, but also to become active members of making and remaking their worlds through the creation of their narratives. Still, the designs have reverberations of the outsider as authority who seeks to release these populations from constraints either of gaining externally defined knowledge or of having voice. We are reminded that, "It would be a contradiction in terms if the oppressors not only defended but actually implemented a liberating education" (Freire 1970, p. 5). The implication is that youth in these settings need to be a more integral part of the instruction and direction of these experiences. Thus the organizers need to pay more careful attention to how participation with the community, from the onset, is a mutually constitutive process of engagement that comes first from within the boundaries which they cross.

To reiterate, these organizations focus on youth agency by asking youth to tell stories from their points of view and contributing stories to a larger conversation of

their worlds. This is a start to moving toward beginning from within the context of the community and youth. SCMW asks youth to write personal stories and DUSTY asserts the "importance of positioning participants to tell their important stories about self and community, and to use those moments of narrative reconstruction to reflect on past events, present activities, and future goals" (Hull and James 2007, p. 255). Starting from youth affords the opportunity for altering the power structure of dialogues between student and teacher. This dialogue is not only important to alter power structures, but also to raise awareness and connect with one's current situation. Freire writes, "The correct method lies in dialogue. The conviction of the oppressed that they must fight in their liberation is not a gift bestowed by the revolutionary leadership, but the result of their own *conscientização*" (Freire 1970, p. 11). The *conscientização,* or "critical consciousness," is necessary for a liberating educational experience (Freire 1973).

With elements of principles that lean toward a critical educational process, youth participation in programs such as SCMW and DUSTY has resulted in a number of successful stories created by youth. The products reflect the intended goals of (1) illustrating a connection to self and community and (2) providing a venue for asserting youth voice. What follows, is one digital story that was completed at SCMW. We examine the potential encoded modes used in this digital story and how alternative decoded messages either liberate voice or reinforce norms.

Example: "The City that Lost Its Way"

The example used for this medium is a story by Valerie (pseudonym). Valerie is an 18 year old Latina high school senior. She is already accepted to college in the fall. Her story is set in Paterson, NJ where she lives. Entitled, "The City that Lost its Way," Valerie contextualizes her perspective of her hometown as well as her hopes for the future.

Digital story transcription:

> The title slide opens with an image of White Police Officers putting handcuffs on a young Black man.
>
> The transitions swipe across to reveal a sepia image of historical Paterson. Music from the 1920s plays in the background. The narration begins, "Paterson has changed over the years. The change that has come is not a good type of change."
>
> The next slide is an image of what appears to be a street fair. A young White boy and two White girls are playing under a colorful balloon-type textile. Adults stand near by. The narration continues, "When I was younger, this time used to shine."
>
> The image transitions again, this time to a cityscape. She continues, "The town's inhabitants would walk around carefully and felt safe."
>
> The 1920s music fades away and a more somber fades in. An imaged of a White woman is shown on a chair in the park. "As I got older, things started to change little by little."
>
> The image fades to black, and a black and white image of a facade with graffiti emerges. "People didn't walk around as much. And the town was less vibrant."
>
> A cross over from the previous image exposes a night view of an empty street. It is raining. There is silence for a few seconds: no music, no words.

A transition brings forth a school classroom. As she speaks, the camera pans across students sitting in chairs and stops on a Black student attentive and looking toward the front of the room. "When I entered High School, the town had really taken a turn for the worse."

The image transitions again, this time to a group of men with bandannas on their faces or foreheads. "Known gang members walk the streets now."

There is a fade to black and then a disclosure of a black and white picture, a silhouette of two youth, a building and power lines behind them. "The shine had left and in came the clouds." She uses a cloud effect over the image as she closes with her last word.

"Drug dealers at every corner… robberies, even murders is what Paterson now is known for." In the background is very soft instrumental music and an image of a crime scene van and investigators.

The circle open transition reveals what appears to be an empty box. "People had lost all hope in Paterson." The box pans out to reveal a moving truck as she continues, "and were fleeing to neighboring states."

The instrumental music intensifies with the appearance of a woman in a crowd. She is holding a check, arms raised in the air. "I for one refuse to lose hope! Paterson, definitely can change." The narrators voice changes. "Citizens of Paterson, rise up and take back our streets. Together we will exile those who have corrupted our city." As the voice is finishing, the image transitions to young men being handcuffed and placed in a police truck.

The next image is of workers constructing a foundation for a building. The narrator, now back to the original voice, states, "I have decided what I must do to make things better. What this city needs is a great leader."

As she says, "And that leader is me!," the image changes to another young woman, arm raised and mouth open. "Valerie [States her full name]."

The final image opens to a city hall building. The narrator closes with, "Mayor! Coming soon." Her full name, followed by "Mayor of Paterson," appear across the screen.

The music intensifies again as the image fades to black. The words "The Beginning" appear on the screen. The dramatic music fades, "The Beginning" remains on the screen.

Encoding: Potential Contextualized Meaning

The encoding of this text is taken to be an assumption and within the context of its creation. It can only be an assumed encoded interpretation as the youth do not provide a detailed or reflective explanation of media strategies and elements that they chose or why they chose them. Instead of making assumption about the conscious or unconscious choice of images, we discuss how film elements (titles, transitions, narration, and music) assert the intended and contextual encoding.

The encoder, Valerie, an 18 year old in Paterson senior, provides a story that situates her everyday existence in Paterson NJ. This story begins with a recollection of childhood, moves through her current view, and finishes with a vision for her adulthood.

Valerie tells her story using non-diegetic sound elements. Non-diegetic sound is the use of sound that is not connected to the source of the story (Kerins 2007). Its purpose is to evoke emotions, offer dramatic effect, and/or to provide narration and assists the viewer in interpreting what the author is thinking (Bordwell and Thompson 2006). Valerie uses each of these, narration and music as both emotion evoking and dramatic effect, as she takes us through her story.

She opens her story with images of a once prosperous Paterson. The music is spirited and energetic, signifying good times. The accompanying narration begins to take us directly from these images of a clean and prosperous Paterson, into an identified unconstructive change. She recalls a different neighborhood in her youth; a neighborhood where people walked freely in public without concern for their safety.

The narration stays even as she takes us into a current Paterson. Along with this, the music changes to a more solemn tone. This music evokes an emotion of sadness or despair as images of solitude, graffiti, gangs, and crime appear across the screen.

She does not accept this reality as taken for granted however. Instead her use of intense dramatic music along with a change of narrator's voice contributes to implying her resistance to this condition. The music and images now put forth a message of possibility, hope, and personal action. It is at this moment that the narrator says, "Citizens of Paterson, rise up and take back our streets. Together we will exile those who have corrupted our city." The message implies that as a collective, the citizens can band together to galvanize change. This message is reinforced with the closing image, a simple black screen overlain with white words: "The Beginning." The final image indicates a need to start to take action, a need for a new beginning.

Valerie's use of non-diegetic sound to tell her story is an effective way for her to voice her experience from within her social context. The music and voice evoke emotions of spirit, then despair, then hope. From her own inside perspective she offers us insights into the current situation of this urban community. Yet she does not portray a perception that all youth in this community engage in the deviant social behavior. Instead, she reveals a determined and intelligent young woman who sees an opportunity to create a promising alternative future. Her story seems to say that she does not feel bound what appears to be a deterministic existence. Rather, she portrays an understanding of her agentic possibilities. To her, this is a city that has lost its way, but in spite of the current conditions, she projects resilience and an insistent optimism that Paterson can gain a new identity.

Decoding: Oppositional Reading

What one sees in a given media text is informed by one's social context since codes, whether encoded or decoded, are "culture-specific" (Hall 1973, p. 132). Historically, cultural theorists have examined the "west to the rest" construct of the globalization of media commodities. They have shown individuals and groups do not simply adopt these commodities. Instead, the commodities are changed and adapted to take on more familiar cultural connotations (van Maanen 1992, p. 17). This interpretation takes a polarized view considering how a non-dominant cultural commodity might be interpreted by a "dominant" culture. The following inferred interpretation is offered as hypothetical to illustrate one possible oppositional read of Valerie's story. We draw on historical representations of minorities to consider this possible read.

The opening music and image of an historic and vibrant Paterson evokes images similar to other thriving cities before the national spur of riots in the 1960s. These

images have become a collective memory of the violent nature of underrepresented groups. Beginning with this image of urban communities could potentially trigger a negative emotional response toward minorities. This emotional reaction would not be against Valerie herself, but rather a reaction to groups that participated in acts that history has attributed to the destruction of the city and ultimately instigated White Flight.

When Valerie moves into describing the situation within the currently community, she uses images that are stereotypically ascribed to urban contexts. These include abandoned buildings covered in graffiti, young men in the process of being incarcerated, and a crime scene set in an impoverished urban setting. Such images, which have been and continue to be used to portray urban youth, might trigger and reinforce these typecast.

In the final segment, where Valerie asserts hope and change, she uses images of rebuilding and rising up. Media has historically represented underrepresented groups as not appreciating or sustaining efforts to rebuild or to change. Deep seeded belief systems about the nature and actions of this group may deter the viewer from seeing Valerie as outside the normalized image of urban minorities.

Although according to our assumed contextual analysis Valerie asserts one message in her digital story, it is plausible that the message can get lost or misread as indicted in our hypothesized oppositional reading. Signs and symbols used in the stories can potentially be taken out of context when experienced through one's own social and cultural milieu.

Broadcast Radio

Perhaps the most notable of radio initiatives is Youth Radio. Youth Radio is a non-profit organization that teaches broadcasting skills to adolescents. Included in the program is knowledge of creating news stories, radio shows, and music for local and national radio outlets. Central to their mission is providing "intellectual, creative, and professional" development in the youth that participate in their programs. Young people are recruited from schools in poor urban districts and from schools that are heavily tracked (Chavez and Soep 2005). After youth successfully complete the application process and are accepted they participate in a 12-week "training" program. Upon completion of initial learning activities, students can apply for internships that enable them to produce news stories. These stories are featured on National Public Radio and other "high impact media outlets." Young people work collectively with adults to choose topics, gather background information on their stories, conduct interviews, write scripts, and produce the pieces that are showcased on public national radio shows (Soep 2005) as well as online outlets including NPR, PRI, and The Huffington Post.

The fact that Youth Radio asserts that it transcends limiting school-based experiences for low-income youth who are confined by public school tracking systems indicates a response to the outcome of historical, social, and politically informed

segregation of schooling. The message implies that this learning opportunity is a response to the inequality of schooling and the results of an imposed hierarchy that results for youth that are constructed as victims of hierarchical power impositions related to race, class, and gender. In the image of Freire's problem posing education perspective, the leaders of Youth Radio see themselves in a partnership with their students. The initial design, however, uses language such as "training" programs. This term in and of itself reflects the notion of "banking" (Freire 1970) in that these programs are intended to impart skills and "fill up" youth with knowledge. The design itself is intended to create a community of learners, and when developed with youth, can be more critically engaging. Educators must "accept that their students possess knowledge and solutions they can share with the teacher" (Duncan-Andrade and Morrell 2008, p. 24) and when they do, students take a role in defining their own learning. Students additionally become social agents that matter in their educational process, their classrooms, their communities and their worlds (Duncan-Andrade and Morrell 2008). Youth Radio employs this approach with students to generate content and produce their news stories. The young people work collaboratively with their adult instructors to examine topics and issues that are relevant to the youth and their communities. One of the goals is to tell and, in some cases, re-tell news stories from the perspectives of youth. This has a social justice/activism component in that the youth are able to address and become conscious of stereotypes, misrepresentations, myths about the life experiences of marginalized youth and their communities. They have voice and are given a sense of agency through their work at youth radio. Topics covered by youth radio interns address the areas of relationships, education, arts and entertainment, environmental issues, family and health. Within a critical pedagogy paradigm, Youth Radio attempts to provide youth with educational experiences and a space to be successful while keeping their identity as "urban youth" intact.

Critical educators consistently speak of an approach to educating youth that addresses the reality of urban life while helping youth see that they can do something about their social conditions (Duncan-Andrade and Morrell 2008). Youth radio is structured in way that urban youth can examine the realities of their day to day existence and create media products that have relevance to them, all while serving as positive role models to other young people in the community. The students involved in Youth Radio demonstrate possibilities and alternative ways of conceptualizing the complex realities of life in urban communities. The media products have the ability to shift the ways that issues are traditionally looked at in their neighborhoods by both immediate and distal audiences. These youth actively and subtly engage in activities that confront stereotypes of urban youth of color.

Example: Legalize Truancy

"Instead of taking kids off the streets, compulsory attendance laws have merely served to extend the streets into this nation's public schools" is a news story written by a girl named Emily. In this story, she discusses her view on why students should

be able to miss school. Her point of view stems from a personal contextualized world. The Grady High School student expresses the rationale behind why she believes truancy should be made legal. She further explains why students should only have to attend classes when they want to.

Transcript of her commentary:

> I believe that truancy should be made legal for high school students. Students should attend classes only when they want to, but after too many absences they should be kicked out. This would have enormous benefits to taxpayers as well as to those teachers and students dedicated to education.
>
> It is unfair to make the education of those students the total responsibility of the teacher and the priority over the education of worthier students. Leading that horse to water does not work.
>
> I don't think anyone benefits from requiring uncommitted students to attend each day and create problems. Instead of taking kids off the streets, compulsory attendance laws have merely served to extend the streets into this nation's public schools.
>
> If students were allowed to leave school they would learn much more about life, responsibility, and the vocational skills not taught in many high schools. The remaining students would be able to learn from teachers who would be able to teach, and the entire system could be retooled to focus on effective and meaningful education.
>
> College diplomas and career advancements are earned through hard work and personal responsibility. These values must be learned in this nation's high schools. So let's give truants the choice to do what they please, and we may all get what we want.

Encoding: Potential Contextualized Meaning

Emily tells her contextualized perspective on the issue of truancy. From a social context perspective, we assume that Emily is drawing on the lived experience in her community. In the medium of radio we can only interpret her intended through the words that she uses. Unlike digital storytelling, radio is not a multimodal text.

Emily begins her story with the economic and political issue of taxes. By bringing taxes into the conversation, it is clear that Emily is beginning to consider the implications of various structures influencing this topic. She extends her examination of these contexts by addressing the social implications of truancy as well. For example, she points to the implications that forcing students to come to school has not only on the teacher, but also on students who truly want to learn. She addresses the student-teacher relations while bringing to the forefront the educational rights of students. Perspectives on truancy normally address factors that influence its prevalence and strategies to decrease its occurrence. However, this Youth Radio reporter provides a novel way of looking at the issue of truancy.

Beyond the issue of truancy this commentary questions the overall structure of schools. Her words shed light on a suggested solution that both allows truant students to stay out of school and evokes particular assumptions on learning. Specifically, her solution takes into consideration the current structure of schooling. By stating, "they would learn much more from life," she is perhaps asserting that the current system might in fact be contributing to why students do not come to school.

Further, this statement suggests that there is equal value in learning outside the classroom walls. Confronting the educational paradigm she puts forth in this news story a suggested restructuring of the power dynamics to allow students to assume more agency in their schooling.

Emily's story emerges from her contextualized experience. It can be inferred that her story is a vehicle through which she examines current approaches to education and challenges this approach by calling for a more situationally responsive solution for urban students. She seems to be grappling with the ever-present stereotype of the urban student who does not care about his/ her learning. In this critical learning design, she radicalizes "aspects of bourgeois culture"(Giroux in Duncan-Andrade and Morrell 2008, p. 34). The Youth Radio reporter does this by arguing that there is need to reclaim the schools as a place to learn for students who are serious about their education. From the perspective of critical theory, this student asserts her voice on the issue. Youth Radio's use of this pedagogical perspective recognizes that students have a great deal to offer to their education. This radio story demonstrates how students not only have a role in the content and process of education in their one-on-one interactions with teachers and other students, but their voice should be included in the structure learning designs, because they ultimately and directly affect their lives. The encoded meaning resulting from this structure, seems to tell a story about personal responsibility, valuing education, and agency in ones education.

Decoding: Oppositional Reading

We situate this alternative reading within the context of our current educational structure and dominant philosophies about schooling and legalizing truancy. In both pop culture medium and the academic realm, discourse on the education of urban youth has painted a picture of apathy, disconnect from education, and academic failure. In particular the academic performance for students of color has been examined and evaluated from a deficit perspective focusing largely on the students who are failing to make the academic mark.

Outsiders may read this commentary as rebellious. For one, Emily's suggestion that students should be afforded their own choice whether or not to come to school might be taken as an attempt to justify truancy. Thus, this youth commentary might also be perceived as a cavalier approaches to a serious societal ill, which instead condones irresponsibility. For example, an outside reader might see that urban youth as incredulously suggesting autonomy in young people who are not yet ready to make decisions for themselves. While Emily might be attempting to alter belief systems about youth responsibility, her message could potentially result in an increased belief that control for these youth is more necessary.

Finally, the act of engaging in a critique of institutional learning structures as well as a critique of her peers might undermine the "dominant" perspective of organized learning. Historically, there is the tendency to see oppressed societies as dependent and Black youth as needing to be schooled, reformed, and disciplined (DeGennaro and Brown 2009). The overarching traditional belief that public

education in the US should control students (Tobin 2005), especially in urban schools (Herr and Brown 2011), could influence the reading. This reading might also be informed by the inherent educational typecast of urban students which characterizes them as low achievers, delinquent, truant, and unable to learn. As a result, Emily's idea of extending learning beyond the classroom walls may also lost.

Although Emily in a unique position to shake up the stereotypes and present a critical alternative to addressing urban truancy, it may be difficult for this message to be read. First, readers are not accustomed to seeing urban youth occupying platforms where they have authoritative voice. For those outside of the experiences of urban students like Emily, interpreting youth media productions in culturally relevant ways can be difficult. The socio-demographic locale of the speaker influences how the message is interpreted and received by audiences. Our perception of what is said is based on our personal interpretation of the speaker. Interpreting this narrative outside of a critical theory lens, it is a challenge to see that not all urban youth perceive education the same. The "outgroup homogeneity effect" proposes that people are more likely to recognize diversity in the attitudes, behaviors, values, etc. when evaluating people of their own group (dominant group) than when they are evaluating those in other groups (minority groups) (Simon and Brown 1987). In this youth radio artifact, the reporter shows us that there are students who do not think about education in the ways that larger society typically depicts they do. There is diversity among urban students that can easily be overlooked by outside interpreters because they rely on stereotypical ways to characterize groups like urban youth. Consistent with dominant view of keeping urban youth in control, allowing "truants to do what they want" as Emily's suggests can conjure up all kinds of images that include delinquent urban youth running wild in the streets creating somewhat of a "moral panic." In order to arrive at the encoded meaning one must acknowledge the writer as someone who has legitimate voice.

Discussion

Engaging youth in the creation of various forms of media expression is a unique way for them (re)image self and community. In the process of constructing narrative, youth participate actively and overtly in activities that confront stereotypes of how urban youth of color are represented and then work to create counter stories. The progression is one that can possibly help to transform the ways in which they, and the issues in their neighborhoods, are traditionally seen. Through distributing their media productions, youth voice can potentially influence the ways in which a larger audience views and conceptualizes urban youth. However, the creation of new images alone will not necessarily result in fostering alternative readings of these groups. We have attempted to illustrate this fact by offering different contextual readings of the same select artifacts created by youth. We have also put forth the notion that historical representations have developed a collective consciousness, which mediates "dominant" interpretations of "other."

In spite of the pervasiveness of how media infiltrates our consciousness, images are only one part of this complex system that helps us to conceptualize self and other. Interpreted and internalized media productions are mediated through various social and political structures such as culture, family, education, and language. These contribute to an expectation of "acceptable" behaviors and of social thought. Images of "other" intersect with these forms of societal institutions, which are largely shaped by people in power. The people in power instill particular language and discourse that helps to inform perceptions. Ongoing cultural discourse reinforces or assists in the development of these views. Through discursive practices, meaning is created. In fact, the language (symbolic and actual) that has been used to describe the "truth" about marginalized groups often materialized into a perceived truth. "Truth" often becomes accepted as fact, and subsequently develops as ideology. The language used to describe the image of "other' is not neutral, rather it is associated with power. When those in power work to create the discourse around "other" then they create a normalized truth (Foucault 1980). While language is never inherently true or untrue, the descriptions assigned to underrepresented groups make it difficult to decide what is actually "true" (Foucault 1980). Images and "truths" are constantly forming and reforming, but in fact take effect when articulated in practice (Hall 2007).

Thus social practices also assist in the unconscious construction of socially accepted truths. Through social practices we embrace a normalized sense of not only the world, but also and ideology about self, identity, and our relations to others and to society (Althusser 1971). "Ideology is not a static set of ideas through which we view the world, but a dynamic social practice, constantly in process, constantly reproducing itself…" (Fiske 1987, p. 258). Yet practices with each other, not solely distant interpretations of them, are what are necessary for fostering an ability for simultaneity of difference to exist. For example, producers and creators from different social contexts need to engage in dialogue around the meaning of their texts. As different schema and practices intersect, there is a greater potential to form and reform our thoughts and eventually our actions with others in the world (Sewell 1992). The breakdowns of stereotypes come through raising consciousness of our own views of self and other. To reshape the image then becomes grounded not only in new creations, but also in discursive and enacted practices across boundaries of participation to mediate interpretation.

What Does This Mean for Youth Media Productions?

Our moderately polarized interpretations of youth media productions are intended to highlight the difference between youth meaning and "dominant" readings. We overemphasize the interpretations and situate them within cultural sociological theory in order to bring forth potential additions within these learning contexts. To inform critical pedagogical engagement, we suggest that youth media productions and readings might be best served when combined with a cross-cultural participation.

These mediated cross-cultural engagements could contribute to fostering negotiated and collectively constructed conversations that facilitate new readings. Additionally, they can provide opportunities to see encoded and decoded meanings in a new light.

The increased availability of both Internet and social media changes create platforms for this negotiation. The potential arises for these social spaces to become public spheres (Habermas 1962/1995) of cultural intersections where multiple perspectives, points of view, and conversations come together to transcend local, social, and cultural positions and subvert projected stereotypes. Specifically, Web 2.0 architectures allow for democratic discussions that can alter hegemonic power structures. In these spaces, learning designs can be created to foster the co-construction of knowledge, and in this case, the co-construction of encoding and decoding. Evidence of youth participation in these spaces illustrates this possibility. For example, Dara Byrne describes online community spaces that become "vital public spaces for (re)thinking and (re)producing social knowledge" (p. 19). These sites can be "useful vehicles for strengthening their cultural identities, for teaching them how to navigate both public and private dimensions of their racial lives, and for providing them access to a more globalized yet unfixed conversation about their community histories" (Byrnes 2008, p. 33). This shift from highly central to more distributed forms of participation bring about a possible modification in how images of marginalized groups are socially constructed.

To take advantage of the platform's architecture, practices in these social spaces need to be organized in a way where critical consciousness is generated and fostered from within and conversations and interactions happen across boundaries. Critical discourse analysis assumes that discourse practices mediate the connection between texts and society or culture (Fairclough 1995). Within these analyses, both the creator and the interpreter can employ a critical approach to encoding and decoding. Without direct experiences, we more often than not embrace, encode, and interpret socially constructed reality in a way that mirrors our own mental image.

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Chapter 14
"More Things in Heaven and Earth, Horatio." Seeing and Believing in Second Life

Carolyne Ali-Khan

Being of Questionable Shape

> My seven-year-old daughter knows that her father congregates with a family of invisible friends who seem to gather in his computer (Rheingold 2005, p. 518)
>
> How (do) we engage students to participate in thoughtful examination of what it means to be human? (Milne 2011, p. 306)
>
> Hamlet: "Be thou a spirit of health or goblin damned?" (Hamlet, Act 1, Scene 4)

Recently a forum associated with the journal Cultural Studies of Science Education (CSSE) was held in *Second Life.* In order to attend, participants needed to create (and inhabit) an avatar. I was one of the attendees and, like many of us, avatars were new territory to me. I entered the conference and cautiously eyed my colleagues (many whom I knew). I was confronted with fellow academicians flying, text-chatting and stumbling around in their similarly cartoonesque pixilated "bodies." Feeling uneasy, I was reminded of Shakespeare's Hamlet, who, upon seeing his dead father, was not conflicted about seeing a ghost, he worried about a being that could so easily not be what it seemed. Was the ghost-king an angel or a devil? What to do, when the way forward suddenly opens to reveal a world that bears resemblance to this one, but both is, and simultaneously is not, *us*?

The netherworldliness of cyberbodies gives me pause. Is it possible that being an educator will require me to have a permanent avatar? Congregating with (as Rheingold put it in the quote above) *invisible friends* makes me question what it might mean to be an educator in the twenty-first century. Will to teach and learn with avatars be to embrace *spirits of health* or *goblins damned*? Will it be to traverse

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the geographies of heaven or hell? Contemplating my foray into this new world I am prompted to several other questions: How should I navigate the slippery ontology of real bodies in technological worlds that transcend physical materiality? Does a world where teachers and students can shed and/or don all signifiers of race, class, ability, etc., effortlessly link-sharing information, herald the promise of progress as it is newly realized in the neutral space of digital utopia? Or does it darkly portend rabbit-holes in the heavily weighted space of the technological divide, where new forms of biopower reign through our most recent way of guarding knowledge in a gated colony? Will communion with avatar/invisible selves isolate us or create community? And while we are cavorting with cyber ghosts, will our earthly physical selves quietly rot in the real world? What should we, as educators, denizens and keepers of these new spaces, pay heed to?

In this chapter I explore some of these questions. I frame *Second Life* as a netherworldly educational space, both real and unreal. Referencing Shakespeare along the way, I question this space through a personal lens and with an eye to insights generated from cultural studies and critical pedagogy. I note Keith Kenny's (2009) observation that, "not only has a mixture of fiction and non-fiction visual media become a major source of our knowledge, but now we can also interact with these visuals" (p. 182). Exploring these interactions, I seek to understand *Second Life* as it operates as that *fiction and non-fiction* where bodies melt and resolve. After journeying briefly through the history and definitions of cyber reality, I present insights from previous studies of education in *Second Life*, share some theories about new technological spaces in education, and probe at the pedagogy of the avatar. Poking at ghosts, I ask what we should perhaps see, what we should perhaps believe, who got there before us, and who or what might be left behind?

Refaced and Ready

> God has given you one face and you make yourselves another (Hamlet, Act 3, Scene 1)
>
> What dreams may come, when we have shuffled off this mortal coil, must give us pause (Hamlet, Act 3, Scene 1)

Before journeying into *Second Life*, I offer brief background. *Second Life* is the copyrighted term for a virtual reality platform that is owned by Linden Lab and hosts millions of players worldwide in simulated worlds (Lindenlab.com, n.d.). In these worlds avatars mimic real life (and then some) as they walk, chat, flirt, touch, run, swim, fly, climb, fall, ride, shop (with real money), build, destroy, explore, and sometimes formally teach and learn. They perform these activities with bodies that are customized cyber/alter-selves. Users can customize these avatars by choosing gender, body type, hair, features and clothing. A number of ready-made avatars are available and can be used as base models.

Searching for my cyber self (in preparation for the forum) I immediately noticed that the majority of the off-the-shelf avatars (including the animal/creature bodies)

are heavily gendered. The *Second Life* homepage should have been my clue. It features a super-cyber-babe in a tiny pink bikini with one delicate manicured hand almost touching her genitals. Does she portend our cyber futures? Masculine ready-made avatar characters have top-heavy V-shaped bodies with overtly broad shoulders, whereas feminine ones are generally delicate-yet-busty figures replete with tiny waists. They embody stereotypically gendered postures (for example – while at-rest – the men generally stand firm while the women lilt). These ready-made avatar cyber-selves appear poised to emulate the tropes of popular culture. They offer us our other self who is not only prepared to be our student/teacher surrogate, but is at the same time distinctly gendered, symmetrically perfect, ageless, clear skinned and super-powered. Avatars are more than our temporary cyber stand-ins, they are poised on the edge of our perfect fantasy selves. What more could I ask for? Freed from *this moral coil* yet beautifully embodied, I will be a perfect ghost, and it follows that new dreams must await me. Perhaps it should come as no surprise that educators who use *Second Life* with students report high interest as a plus (e.g., Esteves et al. 2011) but trying to keep them on track (e.g., Ellis and Anderson 2011) and out of adult (virtual) activities (e.g.,. Inman et al. 2010) as a distinct minus.

What's in a Name?

A rose by any other name…

It may be obvious to say that virtual worlds and bodies cross the boundaries between the real and unreal. But what words describe this new ghostly space? Marianne van den Boomen (2009) casts a taxonomic net around digital cultures, defining them as the "material practices of appropriation, and new media objects as material assemblages of hardware, software, and wetware…configured by human actors, tools and technologies in an intricate web of mutually shaping relations" (p. 9). In effect she argues that we shape the webs that hold us. Pushing back at the idea of technology as merely a tool, she goes on to note "digital mysticism" has framed terms such as '*hyper,*' '*virtual,*' and '*cyber*' as existing "outside of the known materiality, existing independently of the usual material constraints and determinants, such as material bodies, politics, and the economy" (p. 9). David Gelerntner (1991) sees us as firmly glued to these new technological spaces. He imagines that the trends of virtual reality will necessarily lead to "the construction of 'mirror worlds,' immersive electronic simulations tied into real-time monitoring apparatus" (as cited in Graham 1998, p. 170). Moving away from terms that point to dialectical nature of *Second Life,* and in more simply descriptive terms, Steven Warburton (2009) speaks of, "3-D immersive spaces in education" that are defined by "synchronicity, persistence, network of people, avatar representation and facilitation of the experience by networked computers" (p. 415). Chris Inman et al. (2010) cite Dickey (2005) and Robbins-Bell, (2008) to explain a virtual world environment: "exists whether a user is logged in or not, it is populated by many users, it provides the illusion of 3-D

space, avatars represent users in-world, and an interactive chat function is available" (p. 44). Leslie Jarmon et al. (2009) refer to *Second Life* as belonging to "Multi-User Virtual Environments (MUVEs)" (p. 170). Luis Beltrán Sierra et al. (2012) prefer the slightly simpler term, "virtual environments" (VE). Alistair Sutcliffen and Amal Alrayes (Alistair and Amal 2012) use the words "Computer Supported Collaborative Learning (CSCL) environments" (p. 508). Warburton (2009) refers to "computer-generated display". Tuulikki Keskitalo et al. (2011) specify that international avatar based projects should be referred to as "Global Virtual Education (GloVEd)". Linden Lab itself (Lindenlab.com, n.d.) describes *Second Life* as an *MMO* (Massively Multiplayer Online) space (perhaps better known in games such as *World of Warcraft)*. So, avatar-land how shall I call thee? *Mirror world, 3-D immersive space, 3D world, computer-generated display, virtual reality, CSCL, VE, MUVE, MMO?* This rose has many names indeed! I suspect that this plethora of choices reflects not only evolving technology, and that academic penchant of coining neologisms, but also our struggle to put our not-so-virtual fingers on (and in) these new frontiers of space and self.

Old Stages and New Sages

> All the world's a stage (As you like it, Act 2, Scene 7)

The technology may be new, but the ontological struggles of the body within a machine world are not. Dalia Judovitz (2001) traces the virtualization of the corporeal self to the Middle Ages with the advent of the philosophical link between the metaphors of mechanization and the human body. With this history in mind, (and both within and despite the Enlightenment bifurcation of body and mind) perhaps the migration of self to cyber space is more 'natural' than it seems. Donna Haraway (1991) argues, "by the late 20th century, our time, a mythic time, we are all chimeras, theorized and fabricated hybrids of machine and organism" (p. 150). Is she right? Is becoming an avatar academician a difference of degree, not kind? My intellect is already largely externalized. I keep all my appointments on Google-calendar, I write notes to myself in cyberspace and e-mail them so my other self at work will find them. I hold my memories in pixilated word documents and frozen slice of life digital photographs that are held safe in the womb of cyberspace, that is so much more reliable than my "real" rather distractible and perpetually forgetful (human) self. A tweet here, an e-mail there, a blog moment, a *Facebook* update, a comment or a chat, a blind peer review tossed into ethos of cyber space, the appraisals and valuations of Google scholar, the voyeurism of People Search. Like a snail I leave trails of my cyber-selves messily across virtual landscapes. Even without avatar stand-ins, I already smear myself into virtual. In the social context of cyber-bodies '*All the world's* (already) *a* (cyber) *stage*'.

Consensual Hallucinations

> What should such fellows as I do crawling between earth and heaven? We are arrant knaves, all. Believe none of us. (Act 3, Scene 1)

Upon entering *Second Life*, I immediately found myself trying to guess whom (of the professorate) the bouncing, punked-out hunk might be, (did I get it wrong? Maybe I meant the rabbit?). I felt disoriented! William Gibson (1984) provocatively refers to cyberspace as a "consensual hallucination" (as cited in Graham 1998, p. 165). My desire to know "real" identities, combined with my fascination with the unfamiliar bodies on my screen, brought home to me that avatars are (first and foremost) *visual* hallucinations. As such, they belong to a lineage of modern ocularcentrism. I see them as the progeny of our age, children of an era "increasingly permeated by visual images" (Sturken and Cartwright 2001, p. 10). They inhabit a world not unlike our real age of *Facebook*, where visual communication (defined by Kenny (2009) as exchanging messages that include visuals) is the epistemic norm, and Debord's spectacle is not outside of everyday experience but *is* the lingua franca of social life. Avatars up the ante. As they replace text, are moved by and mimic us, I find myself wondering: Do they render us more or less visible? The answer depends on whether this consensual hallucination and the substitution of one body for another is to be 'believed.' Stephen Graham (1998) offers one view of virtual realities in which, "human societies, cultures and economies are seen simply to *migrate* into the electronic ether, where identities will be flexibly constructed…by human agents acting *inside* the limitless domains of constructed electronic environments" (p. 170). Through this view, identity is unproblematically migrated or morphed –we are what we are not –visible now in multiple forms and existing in multiple space. In the crawlspace between earth and ether, the virtual becomes the real. I am not sure I am ready for this.

Simulacra Now

> The time is out of joint (Hamlet, Act 1, Scene 5).

How likely is it that as an educator I will someday find myself quietly absorbed by virtual environments? Perhaps a skim of current uses can give me clues. *Second Life* and its competitors such as *Active worlds* (Activeworlds.com, n.d.) and *Open Simulator* (Opensimulator.org, n.d.) are not shy about seeking educational clients. Inman et al. (2010) claim that Linden Labs alone includes "at least 300 universities around the world" (p. 46). Kirriemuir (2008) believes "three quarters of UK universities are estimated to be actively developing or using *Second Life*" (as cited in Warburton 2009, p. 418). These numbers may be inflated, but many educators do

seem interested in exploring teaching in virtual worlds. Educational virtual worlds are used at all levels of K-12 and higher educational settings (Inman et al. 2010). *Second Life* has an *Education and Nonprofits* travel destination that has (at the time of writing, October 2012) over 70 educational institutions, (secondlife.com/destinations/learning, n.d.). These include Stanford University, the Mayo Clinic, the New Media Consortium and perhaps most surprisingly the United Kingdom's National Health Service (NHS). Perhaps the most telling marker of the popularity of Second Life in formal educational institutions is that some universities have already been banned from using it by Linden Labs itself (Young 2010).

Simulacra is never simple. Within higher education, the affordances of *Second Life* (as a placeholder for reality) are put to very different uses. Different kinds of virtual educational projects employ strikingly different conceptions of the idea of surrogate and of notions of time. I divide these into 3 main categories: Hallucinations, Sprites, and Thespians.

1. *Hallucinations*: In these projects students interact with objects that reference and may mimic known material things, but as these objects are virtual and limitless, manipulating them has no consequences. Avatar students in these projects often go beyond what it is possible, practical, and/or safe to do in real life. For example students are involved in: building 3D objects with participants from different universities (Esteves et al. 2011); collectively translating English manuals into Chinese languages (Wang and Shao 2012); learning about physical properties in engineering (Sierra et al. 2012) performing experiments in chemistry (Lang and Bradley, n.d.). Although participants in these situations use objects that mirror real ones, as 'hallucinations' they are both materially safe and not bound by the linearity of real world time.
2. *Sprites*: In these projects students cross over from the virtual into the real world though the help of virtual selves. These avatars (sprites) help students transcend physical real-world limitations while they impact real-world events. For example they solve "real-life scheduling and management problems" (Keskitalo et al. 2011); host museums and galleries (Han 2011); collaboratively debug computer programs (Sutcliffen and Alrayes 2011). These projects exist within present time and are glued (like the rest of us) to its logic. The students' actions reverberate in non-virtual as well as in virtual spaces.
3. *Thespians*: In these projects students use role-playing as pedagogy. They reference imaginary possible future selves in imaginary future-time scenarios. Some examples of this involve: placing real pre-service teacher-avatars in virtual classrooms with non-real students who present classroom management and behavior problems (Mahon et al. 2010); allowing nurses to enact professional decisions with imaginary patients and patients' families in virtual hospitals (Wood and McPhee 2011); giving nurses conflict resolution skills to help them prevent forms of bullying and symbolic violence common to the profession (Evans and Curtis 2011). These projects don't use the real world as a referent but rather as a springboard for make-believe worlds that exist outside of time.

I may well face a future in *Second Life* as its educational uses are ubiquitous and varied. I differentiate and personify affordances to illustrate how *Second Life* allows time and space to be released from their moorings and to be instead *out of joint* in the service of pedagogy. If "life" can be that malleable, it certainly has educational appeal.

The Body Resolved?

> Oh that this too, too sullied flesh would melt. Thaw and resolve itself into the cyberspace. (Hamlet, Act 1, Scene 2, slightly adapted).

So, I'm buying it. In my minds eye, (and inspired by Hamlet) I see the future: My students and I are completely at home in *Second Life*. We (as avatars) are reveling the life of the mind, while embracing pure Cartesean thought. We are freed from the constraints of *this too, too sullied flesh* (no cell phones to contend with), and this life beyond life is perfect. Finally, undistracted by the emotive burden of pesky physical selves and unshackled from the striations and ideological chains of race, class, gender, ability and other social hierarchies, we fully cohere as a community of practice. I see us flying through virtual worlds, wholly focused, agentic and engaged, wrestling with ideas and ideals in magical classrooms, living the post-corporeal dream.

Perhaps this will happen, and my hyperbole will be warranted. But, it hasn't happened yet. *(Exit stage left).* As it currently stands, navigating cyber bodies is tricky business. The ideal is that, "the virtual movements of the avatar on screenic maps [would] allow for a haptic navigation…based on the transfer of physical movement to another spatial realm. When the navigator moves, the avatar moves along" (Verhoeff 2009, p. 219). The ideal is not always realized. I know, I recall my entrance to the CSSE conference where (despite my having practiced beforehand), several technical glitches plagued me. Speech commands did not work, so I was rendered mute. I was unable to stop bouncing every time I tried to step. My arms and legs were quite beyond my control so I worried that I might accidentally sit on or hit a colleague, (which I found distracting). Although many of the avatars present seemed adept, others (like me) did not, and the rather erratic movements of those who were also deeply clumsy comforted me with visual confirmation that I was not alone.

The practical difficulties of using avatars are frequently cited as a drawback to the medium (e.g., Wood and McPhee 2011). Maureen Ellis and Patricia Anderson (2011) note how technical issues with avatar bodies can have ripple effects: "It can be distracting to have people flying above or walking around aimlessly while an instructor concentrates on leading a classroom discussion or activity" (p. 4). Even when the lack of control only affects a single participant it is easy to see how it could derail learning. It is worth quoting this incident from their research at length:

> I knew your SL office hours began at 7:30—so I appeared in the class area early to try to practice…While I was waiting…I looked at my feet—my feet still were not included inside my boots—and that looked strange. I decided to try to edit my appearance—and I began that process. Alas, I think I clicked on the button to discard an item—thinking it was my shoes—but it was actually my hair. I was so upset to suddenly be totally bald that I immediately began looking for a way to put hair back on my head—I was TOTALLY bald and did NOT want anyone else to see me that way. I immediately searched for any kind of hair—not the blond hair I'd had—just ANY kind of hair. So, I did find some brown hair—and selected something like a style that I thought would be presentable—fast forgetting about my feet that were outside of my shoes! I never even thought about looking back to see if my original hair was lying around!…apparently you mistook my missing hair for a squirrel—and life became even more comical at that point (p. 7)

The amusing anecdote of missing hair highlights how identifying with an illusion of oneself can be tricky business. Inman, Wright and Hartman's (2010) note that, "interactions in *Second Life* are governed by the same social norms as the real world" (p. 53). "The illusion of being there" (Warburton 2009, p. 415) and the "greater sense of presence" (Keskitalo et al. 2011, p. 17) afforded by virtual classrooms can be a draw with drawbacks. Too great a sense of "being there" (particularly when "there" is itself an unstable variable) can lead to the kinds of anxiety found in real social situations without normal relief mechanisms. The research of Sutcliffen and Alrayes (2011) highlights the voices of students who felt, "the avatars are a distraction, because even though they represent you, they do not show emotion or body language" (p. 518). Real human bodies express embodied life with fluidity and emotion, virtual avatar bodies don't. If we accept that emotions and the performance of emotions are valuable tools in collective learning, then an emotional chasm between human and avatar raises questions about the viability of the medium. In addition to this, the scripted, coded, digitized and temporary (avatar) body is not easily controllable and thus ironically a far cry from the perfect project of docility. Overall, it seems that despite technological advances and the lure of flashy virtual selves, our bodies are *still* reluctant to *melt thaw and be resolved.* Apparently my neo-Cartesian dream of being, without the encumbrance of meager flesh but with the affordances of limbs and fingers, is yet to be realized.

Communicating

> A little more than kin, and less than kind. (Hamlet, Act 1, Scene 2)

We may not seamlessly melt into our cyber-selves, but educators and students continue to interact within the confines of *Second Life* using avatars. However crude these current cyber-selves may be, they are a platform for surrogacy and, as such, they communicate for us. One of the appeals of teaching and learning in virtual environments is that teacher-student communication can be more egalitarian and participatory than in traditional classrooms. Instruction in *Second Life* is rarely teacher-centered (Inman et al. 2010). By shying away from teacher-centered pedagogy, virtual classrooms can

provide an avenue of resistance to rigid top down instruction (what Paulo Freire famously called "banking education" 1970/2005) and the tyranny of text. As student avatars engage in learning they are often encouraged to interrogate their virtual worlds and makes sense of it with others. Mirko Tobias Schäfer (2009) describes "participatory culture" as involving "community-based activity determined by a high degree of social interaction and mutual understanding among its participants" (p. 148). Multiple studies (e.g., Lang and Bradley, n.d.; Wang and Shao 2012) argue that a strong appeal of *Second Life* to educators and students alike is that it functions as a collaborative, or to use Schäfer's term, "participatory" learning space.

A review of the literature on the educational uses of *Second Life,* also reveals that another draw of the medium is that it is perceived as an extension of constructivist pedagogy. Constructivism in *Second Life* is understood as occurring through (virtual) participation, as students "create, participate and problem solve" (Han 2011, p. 46) while "play[ing] an active role in the learning process" (Wang and Shao 2012). For example, Keskitalo et al. (2011) argue that *Second Life* fits "socio-constructivist and socio-cultural" paradigms through which "learning is seen as a tool-dependent and social phenomenon, whereas interpersonal knowledge is seen as achieved by its social construction and use of cultural artifacts" (p. 17). Through these views *Second Life* encourages students to be active participants in the learning environments that resist strict knowledge hierarchies.

Are these virtual, participatory and constructivist spaces simply a mirror of real life pedagogical cultural sites? Or are we *less than kin* in cyberspace? Graham (1998) argues that new technologies neither mimic nor transcend reality, but instead work to construct *new* forms of human interaction. In this case the culture(s) of/in *Second Life* are more than funny-shaped collaborative and constructivist spaces, they are sites of new culture. Ken Tobin (2012) points out that culture is never static, it lives and changes in the hands of those who participate in it. This leads me to question the degree of change that is possible in prefab environments with prefab bodies. To use Marshall McLuhan's (2009) iconic phrase, to what extent is *the medium the message*? What does agency look like in spaces where nothing can happen that is intrusive or beyond the perimeters and control of the virtual destination? Eva Illouz (2007) reminds me that real communities are not controlled and purposeful. It follows that real human interaction, agency, and learning in real communities is exploratory, open to the whims and vagrancies of an invading world, and ever shifting. Is then a virtual, über-purposeful, community able to change, challenge hierarchies and create new forms of participatory culture?

Backstage: The Body Left Behind

> Man delights me not, nor woman neither (Hamlet, Act 2, Scene 2)
>
> To grunt and sweat under a weary life, (Hamlet, Act 3, Scene 1)

Contemplating virtualization, Verhoeff (2009) warns us, "movement is not mobility; moving one's hand is not the same as moving around" (p. 216). What then becomes

of the body left behind? Perhaps Haraway (1991) says it best, "our machines are disturbingly lively, and we ourselves frighteningly inert" (p. 152). This insight leads me to dystopic visions, not unlike those of the recent film "Surrogate" (Hoberman et al. 2009) in which Bruce Willis saves a society that has embraced the virtual to the point of giving up the real, *delighting not in man nor woman neither, (but in pixels?).*

There are many reasons why virtual realities need to be grounded in discussions of material realities. The material realties behind the virtual ones may not be pretty. In my own two decades of K-12 teaching I have witnessed an increasingly draconian control of students' bodies. Catherine Milne and Kayla Rubin (2011) note the multiple levels of this, "like Michel Foucault's soldiers (1995), schools are focused on creating docile bodies, bodies that are disciplined to follow rules that legitimate some actions and emotions and de-legitimate others" (p. 630). Critical theorists such Henry Giroux (2003) and Joe Kincheloe (2011) note how the simultaneous neglect and control of children's bodies harms them and undermines democracy. The school-to-prison pipeline flourishes, often ensnaring children who are "guilty" of minor physical infractions of school codes (Fowler 2011). Eric Margolis and Sheila Fram (2007) point out that we have entered an age where "surveillance, as in visibility, is an essential quality of school architecture and an essential function of the teacher" (p. 198). In the light of these realities, avatars are the perfect solution. On the one hand avatar student bodies can be seen and controlled in absolute terms, on the other hand children who are tied to virtual worlds are necessarily sedentary and handcuffed by wires and electronic mice. It would be hard to imagine a more successful form of biopower.

But the question still hovers, 'what happens to that body left behind?' Graham (1998) points out that our experiences in virtual reality may be de-localized but our physical selves are not. He urges us to "consider our state of suspension between these two conditions" (Graham 1998, p. 172). I am not sure that we are "suspended between" these; instead, I think we exist simultaneously in both. Nonetheless, I think he raises a valid point about the contradiction between physical and virtual flesh. Will virtual worlds further disconnect us from the ones we are in? In the real world, children are under increasing attack in more ways than zero-tolerance. Recess has been cut, school food is frighteningly deregulated, abstinence programs flourish, and sports have become the luxury of the few. It is hard to disagree that there is a "war on youth" (Giroux 2012). Michael Mueller (2015, in this volume) examines how youth are seduced by virtual worlds while their bodies rot away. It is possible that the celebration of cyberspace will further obscure the trials and tribulations, *the grunt and sweat,* of real children? I worry that such obfuscation could translate to yet another assault on the bodies of students.

If in fact cyber-realities are the way forward, then in order for them not to harm not only individual real children but also real communities, concerted efforts will need to be made to close the digital divide. Paul Gorski (2005) details how access to digital technologies remains inequitable. He argues that race, class, gender and other social category gaps, are chasms that we are not only yet not close to filling, but that also further alienate those who are often already not benefitting from schooling. Echoing this, Graham (1998) warns us that "socially contingent effects

of new technologies, the ways in which some groups, areas and interests may benefit from the effects of new technologies, while others actually lose out" (p. 176). With all of this in mind, I conclude that while educators may reach into cyber-worlds with one hand, it seems important that the other hand remain firmly outstretched and firmly outside.

Close Curtain

> Good night, sweet ladies. Good night, good night. (Hamlet, Act 4, Scene 5)

Stumbling around in the educational space of *Second Life* I have attempted to pry apart nuances and raise specters. I see many roads ahead, but no clear path. As a postmodern, (not yet post-corporeal) scholar, I subscribe to a postmodern pedagogy "concerned to develop multiple literacies, to rethink literacy itself in relation to new technologies and cultural forms" (Kellner and Durham 2009, xxxvii). I heed Maxine Greene's (1995) rejection of, "inclusive rational frameworks in which all problems, all uncertainties can be resolved." She argues that, "All we can do… is cultivate multiple ways of saying and multiple dialogs in a world where nothing stays the same" (p. 16). In truth I am afraid of this brave new cyber world that is and is not the same. My fears may be unfounded, Warburton (2009) cites a list of unresolved issues with virtual worlds, and comforts me, "Despite the excited predictions of some commentators, it is not inevitable that education will rapidly transfer to the virtual" (p. 245). However, I recently listened to a university provost laud the twenty-first century as a new age, one in which higher education will embrace being increasingly online. It is foreseeable that a combination of the cult of technology and the logic of 'economic sense' will render my virtualization enviable. In this event, I will be shoved into my avatar professorial self, feet first and screaming. I will try to remember the words of Ken Tobin: "I might not even enjoy the process of learning something new, because often times learning something new necessitates changes in direction when you were perfectly happy with the way you were going" (Siry 2009, p. 203). But for now, I leave these musings, and my cyberbody must fend for itself. *(Exit centerstage.)*

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Chapter 15
EcoJustice and Vulnerability in Virtual Worlds

Michael P. Mueller

Many people struggle with the ways their experiences in virtual worlds influence and ultimately change them. This tension between living experientially in real life and within virtual spaces is what I wrestle with here, what I refer to as a *tension*. The reason for this essay is that I have often thought about how science education might benefit from the use of virtual reality, and very few people who think about these things, think about whether teachers would need to be prepared to enter virtual reality and potential vulnerability that would influence or affect their lives, beyond basic navigation skills or by allowing the virtual reality platform to do the training; but there is so much more if we scratch the surface of virtual reality now.

The Link Between the Sociocultural and Virtual Reality

Within virtual reality, there is a large risk that people fail to recognize the deeply embedded sociocultural patterns of thinking and behaviors that influence their lives. There is the risk that what people learn and experience within virtual reality will mediate their cultural traditions and livelihoods in ways not explicitly known. These traditions involve gardening skills, face-to-face talking, birthday parties, asking for directions, bartering with neighbors, and other daily functioning skills. Cultural livelihoods are vulnerable too, such as community festivals, arts and events, food preservation, fishing, hunting, shoe repair, collecting bugs or rocks. In any given community, there are hundreds of cultural traditions and livelihoods. I want to show

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that these things are not separate from people's interactions online and that they become more vulnerable, and may become changed as a result, when people do not acknowledge that their internet and real life worlds are inseparable.

To be clear, the vulnerability I am exploring is the thought of being able to separate one's personal or public lives from their online lives, i.e., what we do online. While on the surface, this dichotomy may seem theoretically possible and it may be deemed as both positive and negative to separate one's everyday experiences from virtual interactions, there are serious dangers worth exploring in this chapter. The topic of vulnerabilities in science education is a large part of what it means to explore sociocultural and historical environments from a cultural studies perspective. I will address the guiding theory for science education instead of teaching practices more specifically. Correspondingly the guiding framework I focus on, namely, ecojustice philosophy, continues to emerge as a way to critique the cultural patterns of thinking endorsed within science education for many scholars and can be used to analyze the tensions between the basic needs of humans and those of nonhuman species and habitats. Ecojustice philosophy is a theoretical tool to engage in conversations about science education now or in the future, or to predict some current implications for the future, and planetary prospects of future peoples.

The object of my work in this chapter is to provide a philosophical exploration of some of the vulnerabilities for people within virtual reality. I do not want to be misunderstood as promoting a dualism between technological worlds and experienced, lived (breathed if you will) worlds. Both worlds are ecological, despite that one may seem apart from "the wild" (van Eijck and Roth 2010), both are integral and systematically inseparable from each other. There is no need to discuss then whether they can be reduced or whether one world has higher status. Although human technologies such as fishing apparatus are relevant to the conversation of virtual worlds, I want to focus on what people typically think of when they discuss "technology" today—iPhones, computers, internet infrastructures, and general electronics that one can purchase at their local Wal-Mart or Best Buy. These are the things that individuals associate with technology. In science, these electronic apparatus are used to compile data, generate and forecast models. These electronic tools are also used extensively to network socially. I focus there, on what people are doing online and how these things create cultural vulnerabilities. Concomitantly I will approach some positive implications for science education. I use pragmatist philosophy (Dewey 1938/1963) to analyze the apparent dichotomy between real and online and these things in relation to ecojustice—fairness applied (Mueller 2009). Pragmatism is a way of grounding theory within contextualized situations for the benefit of learning something about the encompassing world. Virtual worlds are interesting from the perspective that they serve as a medium for youth growing into adults who feel along the way, the pressures of their societies.

Ecojustice Philosophy

The educational philosophy dealing with fairness applied to both sociocultural and historical environments and the needs of natural systems is ecojustice philosophy (Mueller 2009). Ecojustice scholars argue that schooling is a very small part of the larger educational world, and therefore school science is a small part of education. The idea of justice applied is something that I have discussed in much more detail with regards the cultural commons, or human systems (economic, politics, values) and with regards to the environmental commons or the needs of natural systems to survive, thrive and reproduce historically. While ecojustice theory draws heavily on science and scientists for information about the health of a local stream or the world's oceans, there are dangers to relying exclusively on the sciences for justice. Therefore ecojustice theory has emerged as an integrated theory of justice for assessing society in general and within science education three areas of school science more specifically. First, there is a focus on ideologies that are part of and endorsed during particular time periods, and their residual influences in the schools. Second, there is a focus on the empirical descriptions of the cultural and environmental commons and what occurs when ecojustice appears to be embraced and valued. Third, there is a focus on ethics and morals as part of how to engage communities for responding to the local concerns of both cultural groups and environmentalists.

Ecojustice is a tough theory to wrestle with because there are really no clear-cut answers for problems. Considering different problems and situations makes the process of thinking and acting in relation to ecojustice more significant. Scholars interested in using ecojustice philosophy to analyze what they are doing may research ideologies, curriculum, or education policy. They may look beyond schools to see where there are risks and threats for individuals, communities, or the larger environment. For example, I have called attention to the need for science education to develop and discuss longer-term ideas of change and confluence rather than using shorter-lived ethical imperatives or "ecological crisis" as motives for change, despite that fear is not always a negative thing to experience. One specific area of concern for ecojustice theory stretching back to Chet Bowers (1997) is whether technologies developed within the last 300 years have rapidly marginalized cultural ways of knowing that may have a lesser impact on the Earth. For example, Bowers often discusses computers as a problem for cultural groups such as the southwestern tribal communities in the United States, where children learn what it takes to make lives within highly technological world while spending away time that could have been used to preserve and protect their cultural history. Bowers explains that on a smaller scale this thought of "doing other things more technological" comes at the expense of learning traditions and skills that conserve nature or ways of knowing that protect languages and cultural heritage livelihood. He would say that these tribal communities

serve as a metaphor for what is happening around the world, namely, the loss of cultural traditions and environments. He will also argue that inherent faith in science and technology is a major concern. A distinct connection between the loss of cultural knowledge and community skills and the integrity of the world's ecosystems is the hallmark of ecojustice theory, which is where ecojustice scholars place their attention and evaluation of fairness. Where I differ from Bowers is with the idea of *developing cultural communities*, where the nature of culture for many cultural communities does not always come at the expense of their previous traditions, where *science* embodies the ways in which many cultural groups have evolved over time (Mueller and Tippins 2010).

More complex understandings between technology, community traditions and livelihoods have been witnessed in science education within the past 10 years. For example, George Glasson (2010) explores technological advancements and the preservation of cultural values and skills that could be lost with such trends, being cultivated more fully through the use of advancing digital technologies. Where there are generally tensions between losing ways of knowing and living to the rapidly emerging technologies (for example, face-to-face conversation for cell) the logic is that people will always negotiate the advancement of their cultural communities if technologies encroach on both the protection of their identity and the environments that sustain their lives, along with the future lives of the unborn. Although the outcomes of this mediation are not always positive, for example, when teenagers increase their reliance on the internet and market for information, the vulnerabilities are felt throughout the community and will ultimately influence the ways in which people are treated, including how they respond to such reliance. Sometimes communities became more vulnerable because they adopt technology, and sometimes they become stronger because they learn how to mediate new toys. Ecojustice theorists have demonstrated how the traditions and cultural knowledge of entire communities could have been lost to technology and the industrialization of nations (Glasson 2010), yet how ecojustice philosophy helped to analyze how to use these emerging technologies to support protecting food security. By using digital phones, students were able to learn historical cultural traditions or the skills that were needed in order to cultivate organic vegetables and local foods. While ecojustice philosophy is applied to digital technologies such as iPhones and internet video, it has not been applied to virtual reality such as what I will now do.

But first, I want to give a description of my experiences researching the virtual reality platform Second Life™. In order to do this research, I spent at least 3 h in Second Life for more than a month every day. I became exhausted, absorbed and sick, but still maintained my research for a specified period of time. My intention was to delve deep into the virtual world while realizing I scratched the surface of what really happens and could be done within one internet platform. I realize that there is much more than I could ever capture in this one chapter. The reason I selected Second Life is because of a science education conference that was held within this virtual world and the many other institutions that use it. What makes Second Life really intriguing is that similar to Wikipedia and other shared access internet environments, the vast majority of content is created by "players." I tread lightly on

the notion of "players," recognizing that Second Life is both a game and not, and for many people what occurs because of SL has consequences. Now let's move on to explore SL.

My Lived Second Life™

I now live as *Bret*[1] in Second Life® (SL), a three-dimensional virtual world. Bret is an *avatar*, or unique recreation of my self; but also known as a virtual resident, which is deeply influenced by my understandings of being the avatar. I created him to be physically attractive with broad shoulders, slender, and muscular—not an inch of fat. I have a tan body, blond hair, blue eyes, and evict masculinity through my virtual essence—at least this is how my avatar emerged in SL. Eventually he has changed a few times, but more recently, he is like me in that he has shorter hair. In SL, there is no temperature and I do not feel pain. I do not need to eat. Of course these things are constrained by my real life (RL) (i.e., need to eat). In SL, there is no "sickness" and we do not deal with illnesses of real lives.[2] We continue to create our own virtual reality by flying around, building homes, and worlds within worlds where there are diverse avatar communities. Experience is virtually owned by Second Life residents, where there are millions registered to purchase virtual space from each other, clothing, the arts, and behavior sequences. People get married, have families, friends, and play out their fantasies in SL space. The name 'Second Life' implies that one can live out another life in fantasy and many people suggest that one can do anything they want in SL; there are no limits.

The Second Life Terms of Service permit residents to retain ownership through copyright or intellectual property rights of virtual objects or avatar functionalities. Clearly there are creations from RL including mythical creatures, vampires, and Star Wars characters. There are those who will call this customized chat network a "game"—but if games are limited by the programmer's imagination, the only limit for SL residents is their perceived cultural imaginations, knowledge, and behavior. Currency is the most obvious transported article from RL. The Linden ($L) dollar is used purchase things, where roughly $250 L converts to about $1USD. There is a market for everything from skins, to jewelry, hair, vehicles, plants, and animals. Every idea, thing, or pixel in SL is considered a significant asset and has a unique

[1] All names are pseudonyms throughout this manuscript including my own avatar. The purpose of this concept is to protect the identities of individuals whose minds helped to construct my description and in many ways my analysis of vulnerability.

[2] Second Life has become much more accessible for people with disabilities, at least that is what I have read about—people who are blind, hearing impaired, learning disabilities and so forth can now access Second Life through different technologies used to assist them. However, very few people embody anything other than able-bodied, healthy, strong, physically fit, beautiful and young avatars. I question whether it is healthy to be something you are not in virtual reality, especially, when it has been shown here that there are vulnerabilities in virtual worlds.

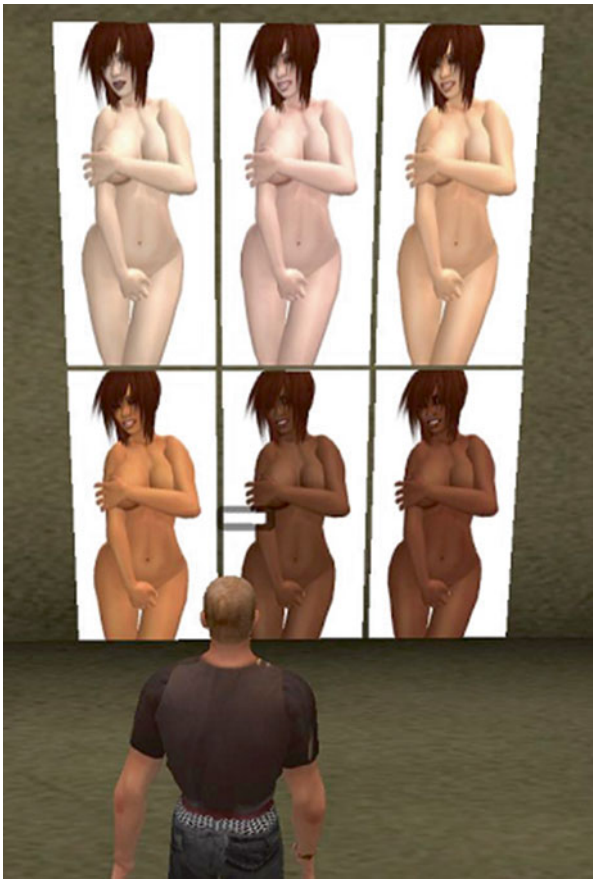

Fig. 15.1 Avatar "skins" for sale

identity (UUID or universally unique identifier number). There are educational, scientific, corporate, political and artistic venues that appear alongside advertising.

To enter SL, I selected my user name and avatar appearance. There were six apparently male and six female models to choose from (Fig. 15.1). Becoming avatar is extremely frustrating, one that took me hours and hours to figure out, despite a walk through tutorial and instructions that can be downloaded. Becoming avatar is a one to one interface without social interactions, albeit there are other emerging avatars and I suppose that one could ask another how to do certain things such as selecting clothing, eye shape, and so on. My first impression of SL is that it is all about money, sex, consumerism, and the hyper-sexualization and homogeneity of human bodies. Becoming avatar is essentially an individual process, a sink or swim process of learning how to navigate the different menus. Learning how to walk, run, fly, and teleport are simple despite the difficulty with other aspects of SL. Immediately, virtual reality is enticing and exciting and the 3D umbrella makes things stimulating

as I look around at the signs and symbols representing how to function. After playing with my appearance for more than 2 h, I finally decide that my avatar embodies some of my traits and aspirations. The choices are nearly endless, and most of them focus on facial features: head size, stretch, shape, roundness, length, face shear, forehead angle, brow size, upper cheeks, lower cheeks, and cheek bones. And that's just for the head. There is body, eyes, ears, nose, mouth, chin, torso, and legs, and then subcategories within each of those appearances. Avatars are highly individualized. If one knows their exact proportions from RL, they can use percentages and nearly recreate themselves in SL. Many, if not most of the people that I talked with, said they tried to create the avatar like themselves. Some people sent me their real life photos or had them posted on their avatar profile screen, and some of the avatars do indeed look very much true to appearances.

At the end of the tutorial experience for learning to navigate basic movements, there are four basic billboards: One can go shopping, explore places, meet others, or find help from the Lindens. I would be remiss to note that SL is a product of Linden Labs Inc. I decide to go find an interesting SL shop, *Action Surf Skate*. Within seconds, I am teleported and looking around at clothing. I see a nice pair of cargo shorts, similar to what one might find at Old Navy stores in RL, but the price is $200 L (or <$2.50USD) and I don't have any money yet. There are advertisements typical of what you might find at Gap or other retailers in mall stores, but some of them are modified to display avatar 'models.' Of course, there are skateboards, board shorts, bikinis, dresses, and stylish clothes, but I'm looking for virtual surfboards! There are no cashiers and the shopping is very individualistic (although sometimes other shoppers appear)—just point and click. I've found different women's hairstyles for purchase, women's skins with make-up, and there is music playing in this part of the store (Fig. 15.2). Appearing on the advertisement are very

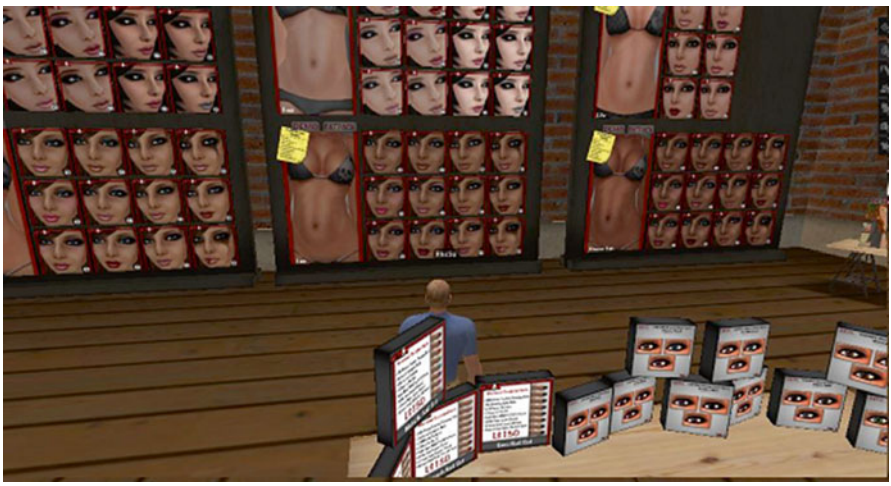

Fig. 15.2 Appearances, body parts, hair, makeup, and clothing are fashioned after trends in RL

attractive women that in RL would appear mostly between ages 18 to 35. (Ironically, most of the people I meet in SL *say* they are between 18 and 35 years old.) I stop at one women's "skin demo fatpack": "Women's skin series MIRANDA INCLUDES… Miranda Shape 5'8, Prim Lashes, Sculpted Nails (French Nail Set), 8 Eyebrow Shapes, 6 Eye Colors, Height Detector, and Information Notecards". The avatar's body is sensual with a bikini top and a large footnote—extreme tan.

At the bottom of most of this store's advertisements, there is a note that one can "gift" the item to other avatars. I'm reminded that since my first days in SL, I have found many other places in SL to shop and there is an entire SL marketplace site (https://marketplace.secondlife.com/). Some people I have met in SL are avid shoppers, spend hundreds of US dollars weekly on pixels, and may even leave their avatars motionless for hours while they are fueling their online SL addiction. The idea that everything is available for purchase corresponds well with RL today.

While there is a room for male hairstyles, I'm going into a room with different vehicles. I like this candy red convertible with a surfboard displayed in the passenger seat, but wonder if the octagon shaped wheels matter in virtual reality. In RL, these wheels would create quite a vibration! This car is called a "Surf Rod" and the price is $1,299 L or $5.41USD. I now find what I came for—surfboards ($399 L or more than $2.50USD). I should mention, a Linden conversation is approximate but not exact USD. Regardless of whether the initial upload is in USD or Euros for example, once they are Lindens, the Lindens are part of SL economy. So it does not matter if one loads them in USD. There is also furniture here, beds, benches, trees, and other things that one could use to décor their individual spaces. People even purchase real estate, sell home spaces, build homes and rent property. (Eventually, I became convinced that I needed to buy a cabin on an island in SL!)

A few days into SL, I'm dancing through dance animations, where I teleported to find some moves. In order to do certain things in Second Life, one must purchase animation overrides (ao) which will move your avatar (e.g., Street/Hip Hop) but now I'm doing the Lemon Squeezy! After teleporting and talking with Becca, someone who I met in a Loft Location, I'm here on *xstreet*, one of two places that were said to be interesting. In xstreet there is not an avatar in sight. But there are buildings that look like skyscrapers and an arena for concert venues and other cultural events in SL—I'll try xstreet later. Next, I am talking with Ruth, a SL clothing designer from RL Austria. There are some shorts that I'm learning such as LL (the Lindens) (see Appendix 1). People online use a lot of abbreviations for RL expressions, such as 'brb' (be right back), 'afk' (away from keyboard), 'k' (okay), and facial expressions; O). Ruth tells me that people don't talk much about RL in SL because they consider these "two separate worlds." This statement sparks an interest for me. She tells me to be careful about saying too much beyond my RL age and where I am from. She cautions because I am a "noob" (newbie), people won't talk with me (as much as they would if I had some experience here). Ruth says I should be careful talking with noobs because they will stalk me. She says that newbies don't know what to do, so they stalk people and make stupid things—"they think SL is a game and they think that you can play here, I don't know." She teaches me how to use camera angles in SL, and says, "yeah that's it…you learn every day

and that's what newbies do. They visit places." As a fashion designer, I ask Ruth how long it took her to create her avatar exactly the way she aspired it. She replies, "well that's hard to say when you're not a newbie anymore….maybe after some months." She continues, "it also helps you to make your avatar looking better, so other people can't see that you're a noob;)" "buy shape, skin, ao, clothes that are not freebies, freebies = free stuff" I ask, what is an "ao"—she replies that it is an "animation override—that's the way i'm standing and walking….newbies usually don't have an AO so when they are walking it looks like a duck or something like that;)" I asked Ruth how close what she looks like in SL embodies what she looks like in RL, and she says, "well I created my avatar somehow to look like I would look in RL or I would want to look in RL" "some people create the avatar to look exactly like in RL and others change gender… or others look like children or old people, or somehow fantasy creatures, or animals…i tried almost anything out and ended as a 'usual' person… I think i'll stay that way – human;)" I ask if she thinks that the clothing she designs influences RL. "I think it's the other way round. RL clothing influences SL clothing." I say, "yes i see that a lot of things are RL. People don't have to wear clothing, but they do, for example." She says, "well it's somehow like RL here…if you get naked in public it embarrasses people in SL so everyone wears clothes here and if someone doesn't it's mostly by accident." Why do people join SL, I ask. She says, "there are mostly 2 things why people join SL: 1. make money 2. They want to have sex lol" (i.e., laugh out loud). "So most questions newbies ask: where can I make money? and where can I make sex?" I ask why so many people are attractive and she says, "you know most people are beautiful in sl, perfect face, body…like models (btw that's also a job in sl – model) and don't want to look like anyone else, so they decide to be fat in SL for example or old or whatever." There are other jobs in SL, "designers, models, photographers, assistants, prostitutes, strippers, dancers…and builders." She says designer is the most popular job in SL, it's big business." Ruth says, "there was a time when not much people could design and build, then you could make a lot of money but nowadays there are more shops than people in sl and there's a huge competition….and there are already so many good designers here that it's hard for someone who already started." But she notes, "nobody is interested in RL companies here lol" As we are talking the sky gets dark and some lights go on nearby. I have never seen this. Ruth says that you can tell what time it is in SL by looking to the upper right corner—it says 6:35 AM PST. She says that if you want to meet friends in SL from different time zones, it's easier to say, "Let's meet at 3 PM second life time (SLT) (PST) than saying 3 PM at your time." When I ask Ruth about the lack of temperature and clothing styles to match, she says, "yes, there is no temperature…but if you have your own land you can make spring/summer/fall/winter and you can also see a trend in fashion…now it's winter in RL, so there's a lot of winter fashion created in SL and in summer most people create summer stuff….so fashion is rather oriented to RL seasons".

Another day, in the Peach Café on Winterville Cove, I meet Reese, for short. She is the owner of this café, a place where people hang, make coffee, espressos, and other drinks. The music is relaxing and most of the people are noobs. Reese is very helpful and explains how to stop animations and where to find free clothing. She

helps noobs. So I teleport to a free clothing store and retrofit my appearance. Reese pays for her part of the simulation because she enjoys meeting new people in SL and because it provides a place for her to display some of her artwork, which people can purchase to decorate their own SL homes. She also designs homes and other home accessories. Her café thrives in part because of the tips she receives to help support the rent that she pays in RL to LL to support a café place. Her café is interesting, because unlike many cafés that we Americans use in RL, her café encourages social interactions and conversations. The café is where I met several of my 'best' friends in SL, people who live in England, France, or the U.S.

Interestingly avatars do change clothing, especially the ones who own a business, while most avatars save their facial and physical body appearance for recognition. Some are incessant about their appearance and the more time one spends in SL, the more like others one becomes. Many avatars embody their RL aspirations. On the issue of owning land, that's interesting too. You have to pay LL about $1000 to have a simulation space (sim). There are more than 35 universities and other educational or scientific organizations and it would be interesting to know how much they spend on sim space, or whether there is some negotiation with Linden. There is a rent to LL; they profit in the end—ultimately everything is pixels. So if LL goes away, then so does the entire SL network and all of the things RL owners created. In the end, LL decides and controls access to SL content. For some sims, there are age verifications. For example, adult content areas are regulated and one must demonstrate that they are adult "enough" to access these areas, either by verifying a driver's license, passport, with social security number, or with one's credit card. Clearly young children get through depending on how savvy they are within SL. Some people use SL "voice" features instead of type to verify the age or gender of an avatar. While there is another platform in SL for ages 13–17, the plausibility of under-aged avatars is always lurking, and you can tell that some people get annoyed by those who pretend to be RL adult within SL. To provide an example, one can "right click" on another avatar's body to access their profile. People post on their profile the information about who they have interacted with and how others have treated them in SL. Here is an example profile:

> If you IM [instant message] me:
>
> 1) Have a sense of humor. I dig that.
> 2) Be age verifed and NOT a child avatar. ANY game with the sexual capacity that SL has is no place for child avatars, period. "Oh I'm just short." You're in pigtails sucking on a lolipop in an adult fucking sim. You belong in jail.
> 3) If you're an effed up lookin' avy you better have a LOT of #1 going on.
> 4) "How R U?" and "U luk gud" = instant ignore.
>
> When you stand apart with humor, artistry, and sincerity, you get my attention

The point is that the avatar profile serves as sort of an advertisement about who the person is behind the avatar. There is even one place for information about SL and another place for information about RL, albeit very few people share their *R*L.

Another day, another dance—funny thing is my avatar has been talking with others for some time now and he is not even "tired" yet. He doesn't get worn out like I

Fig. 15.3 Environments/habitats are designed pixel by pixel, emphasizing desired qualities

would in the RL. Keep in mind that some people log into SL and leave their avatars "in world" (an expression that is often used by people in SL) on AFK or BRB status. It is fun talking with people in SL without the frustration of missing a word. Avatars do not have to compete with background noises, music, and can even turn music off in the RL viewer if they want to. It is as loud as the volume controls on my viewer now. Techno/ house music is something I enjoy in RL. And there are many options including live music venues in SL I have seen. (One woman tells me that she puts her kids to bed in the evening and then does evening shows, as a SL musician or pianist, a profession where she makes a salary or tips). In addition to music and clubs for dancing, there are movies, games and other experiences from RL that SL avatars enjoy. Because ecological systems are designed in SL, there are different species and habitats than would be found in RL (see Fig. 15.3).

Habitats are interesting from the perspective that many designers select the most romantic or aesthetic aspects of the natural world to place within virtual worlds. Although there are nature preserves, underwater sims, and other beautiful environments, the chaos and unpredictability of nature is controlled for and simultaneously changed.

A new day at the café I have been frequenting and the owner trusts me enough for a tour around the parcel she owns in SL, including a home she designed with SL tools. It's no surprise that the house is artistically designed as the arts are what she specializes in RL. Many people I have met have degrees in arts or computers, marketing, advertising, dancing, fashion, and other skills that translate nicely here. She shows me how a security orb protects the parcel when she is not home. Her SL home is masterfully designed; there are art works on the walls, a vineyard and blanket of snow. There is an incredible view of the ocean and mountains from her place as well as neighboring homes. She says she loves it here and there are many realistic textures such as wood stacked in a pile under the house. I notice cats, but no other animals, not even birds in her virtual ecosystem. She mentions to me days later that the birds migrate for the winter but will be back in the spring. After all, she

has these birds in her SL inventory to be placed in spring. I notice that she is popular with noobs and helps them to become successful in SL, make the most of their experience, and sincerely helps lessen their frustration. She also shows me her studio, or art gallery, where she displays her artwork next to the Peach café. To make Lindens, she designs homes, rugs, artwork, or details and imagines any aspect of virtual reality desired. Her imagination is marvelously visible in the things she has created and designed for her SL and she shares this passion for SL with others. It is truly amazing. She spends 5–6 RL hours on SL every single day. But she is retired from her RL work, and since so many users are heavily invested in SLs, they are single, unemployed, stay-at-home parents, and they work at home.

There are a couple aspects of communication and conversation in SL that differ from RL significantly. For one, when I speak with a group of avatars within a simulated location, they can all "hear" and have the opportunity to interact locally. This provides a way for avatars in different, even far removed, areas of the parcel to interact and communicate with each other. There is background noise, but noise is mitigated by the conversation and the ability to multitask in conversation is remarkable—enhanced within the virtual world. One can listen to music, hear others, and then IM for a more personal conversation, while still attending to the location. However because of the group function of local chat, ideas and jargon are taken out of context if one comes into the conversation from afar and sometimes things being written in local chat are said to be offensive because of the diversity of ears. People come to SL from all over the world and expressions are not understood the same way everywhere despite that almost everyone in SL "speaks" Euro-English. The idea of talking with others who one does not know is exciting but challenging. There is no way to know if avatars are honest and relationships take a lot of time, just like RL. But there are opportunities for conversation that differ significantly, for example, café spaces where the music and landscape do not take away from it. Once added to your friend list, a friend can be IM even if they are not within view. There is a notification that allows friends to know when others log in to SL online.

I play with personal space quite a bit within SL. What I mean by personal space is the space that people psychologically employ in RL environments depending on sociocultural conditions that made them aware of the space around their bodies. In SL avatars also employ personal space. There is a difference between talking right next to another avatar where you can see their avatar and talking with them, but not being able to see their avatar in a far removed place. It is as if "seeing" the pixels that make up avatars help to carry on a SL conversation. Also other avatars are aware of what is going on around them in the viewer. If another avatar is too close, they oftentimes move away. If sat on or bumped into, avatars do the same—they often move away or it makes them uncomfortable. (One of my friend avatars created an ao where when she is bumped into, she kicks, punches, bams the other.) Avatars have similar psychological perceptions of personal space similar to RL personal space. Interestingly, while RL personal space corresponds with culture, in SL, it is not easy to determine whether a person's culture plays a role in psyche.

The most interesting aspect of my days in SL have come from my interactions with hundreds of people who discuss the notion of a dualism between their RL and

SL spaces. Some people get married on SL and have children even. Some find their families on SL or they develop relationships with people who serve as their mothers, father, and siblings. People develop different characters and may have as many avatars as they can develop personalities or relationships for—called 'alts.' These alternative avatars serve to protect personal spaces for many who say that they would not be loved, cherished, trusted, respected, flirted with, or consulted, without the SL confidentiality that is provided in the online platform. While some claim to be just playing the "game" and vigorously argue that they can "log off" at the end of the day or when things do not go the way they would have otherwise wanted, they make a poor argument for the separation of their lived personal lives and the online roles that they play with, even when they are taken to the extreme, which seems to be the case with vampires, werewolves, or role play other avatars.

The last thing I want to address before moving on is the love that people have for their avatars and the environmental spaces they have designed for them. Often when I discussed people's aspirations for their avatar, they discussed living lives that were imagined, fantasized, or manipulated and designed with the most desired characteristics of humans, nonhumans, and the natural world. People said that they loved looking at their "Barbie doll" and dressing him or her, they loved being in their environments, sitting there spending time looking at what they created and dreaming about the virtual space created and designed for their aesthetic pleasure. The essence of their thinking in this sense reminded me of an evolving artistry. This last part of my description of the research context comes from many hours of talking with individuals who honestly shared their ideas, aspirations, and behavior. Some of these relationships turned into friendships with people who live in far off places, where I may never visit, but that nonetheless helped me to reach further. For that, I am forever grateful. Now let's analyze the vulnerability idea more fully.

The Dangers of Virtual Reality

> Beware of all enterprises that require a new set of clothes (Henry David Thoreau, 1817–1862)

When I apply ecojustice philosophy to the experiences I have developed on SL, I realize that there is much more to the issue of vulnerability than reality versus ideas. There are positive aspects to SL that can and should be explored more readily in science education and other educational domains, such as the possibility of engaging teachers in virtual role-playing scenarios and environments for learning about how to teach, how to monitor species and habitats or practice for science teaching. I can imagine how virtual reality might prepare new teachers for school. There is a large component of role-playing that already exists and it is highly plausible that the SL role-play could be used to benefit science education globally. However, my concern here is that these things will be done without the necessary risk reduction that can and should accompany them. I have talked with so many scholars and community people who have never entered SL or any other virtual reality platform and

jump to the conclusion that either these people are abnormal or that they do not have functional social lives in RL, where SL encompasses space for these interactions that would normally not occur. While this assumption may be true for some of the individuals in SL, it certainly does not include the vast majority of users that I interacted with—these people I talked with for sometimes more than 6 h every day. (Many of these people were logged on all day long.)

The critics are more often the ones who suggest that virtual reality is a "game" or social networking platform for introverts or people who are not normal when what I experienced in SL is a place where the vast majority of people are not secluded home loners without lives, but have interesting stories and embodied life. My claim is that the critics, the ones who call SL a game, are either inexperienced or new to virtual reality (and I am not referring to MMO RPG games) or they have never invested the time to find out what SL provides in terms of social experience. I argue that these people, the majority of people in society, considering that people in virtual spaces comprise very few (Linden Labs reports two million subscribers, with approximately 60,000 people who actively log into SL at on a regular basis), inadvertently perpetuate the idea that real life and virtual life is somehow separate. While it may be true that on the surface a short existence in SL can be separated or distinguished from what people constitute as experiences in their real lives, the dichotomy between RL and SL is quickly dissolved as one becomes more involved. While the more intellectual person will say, of course the divide between real life and virtual reality is clearly impossible, many people believe they can pull it off, and there is a real danger when people fail to recognize a struggle with this notion.

Even some of the more experienced virtual reality users claimed that they could log off and return to their normal lives while living dual existences separate from each other, and when confronted argued vigorously that SL exists apart from RL. When I challenged them with the claim that I had not seen anything that surprised me in SL, some avatars employed interesting graphics or changed themselves into a ham or activated interesting weapons that shot out bunny rabbits, melons and so forth. The reality is that even their robot animations were situated in shared imaginations that is, avatars take the forms of animals such as ravens, hybrid animal human designs and the vast majority of avatars regardless of form, are conceived with anthropomorphisms. There are no clear signs that avatars are deaf, deformed, diseased, or detrimentally incapable of performing the activities of able-bodied humans with special powers (for example, the capacity to fly despite that some locales do not even allow that). In fact, some of the ao's and "scripted event sequences" are designed specifically to poke fun at mentally or emotionally disabled people, or even disabled people. Do not misunderstand that I am saying this poking fun does not occur in RL, it just seems much more difficult to face one who has to deal with these issues in RL. It is the case that SL people feel less constrained by community social values that may censor explicit displays of bullying. Without facial and bodily cues, much is lost within virtual reality. While social cues play an important sociocultural function in the community, neighborhood and in schools to regulate the ways in which people treat each other, they are mostly absent in

SL. Some people prefer the temperance of these expressions to the ways that others look at them in real life, and likewise, prefer SL to RL for socializing. The intolerance for difference, or deformed, or diseased humans is clearly visible. I met several avatars who provide information in their profile about being proud to be a particular race or cultural group, but most did not select characteristics that would have represented their RL appearance because they were not available for purchase or did not want to be other than stereotypical SL white and homogenous. One of my friends has a sizable scar in RL, and yet their avatar is 'perfect' in SL. This homogeneity creates an interesting thought experiment when we consider the ways in which parents are now engaging in genetic counseling and scientists are selecting some traits and not others in the world of genetically modified species. The plausibility that SL creates a thought-experiment for what would be selected if people could liberally select what they genetically desire for their children in RL is an ecojustice issue worth exploring in more depth because of the vulnerabilities. These vulnerabilities include the loss of entire cultural ways of knowing, systems, languages, phenotypes, and terminator genes patented and owned by corporations. What happens when entire thinking patterns and behavioral systems succumb to the pressures of those who want to design the human body and our environments?

What if RL were more like SL? In most cases, being able to "breathe" underwater, wear clothing not appropriate for weather and seasonal conditions, or talk across spaces are superficial differences. But these things are highly desired. What is being risked in a world, where no one really knows who you are, is a lot different than maintaining a reputation, physical appearance, and status quo in RL. But the seduction of physical features, that meet in many cases the aspirations of the user, or the life-long experiences that drive the social imagination, are sources of design for many features of SL that make it feel and behave like virtual reality. While I do not discuss it in depth in this analysis, the ability to buy just about anything and the entire SL shopping or marketplace experience occurs with money, and I could write an entire chapter based on the hyper-sexualization of SL avatars. These things are deeply influenced by capitalism and stereotypical 'beauty' ideals. While I strongly believed going into the research that my main critique would be taking on the influences of capitalism and status quo beauty, it become much more the interest of mine to explore why these things made their way into SL ecologies. And the real answer to that question lies with dissolving the SL and RL dualism. But I am sure that one could point out the same influences on people that occur in RL with a strong emphasis on consumerism and hyper-sexualization, such as the loss of cultural knowledge, traditions, expectations, aspirations and narratives that have for hundreds of years, in some communities, increased market reliance. My concern is that virtual reality could be used to challenge these things but does not, and like the RL where there is also a deemphasis in schools on ways to lessen our dependence on the market, SL only heightens this sense of reliance on the market. While I have not explored other active virtual reality platforms, I have listened to the teachers in my classrooms describe how other simulated environments are also bent on consumerism and the hyper-sexualization of characters to seduce players. Without

the mediation needed to guide youth into these increasingly popular digital arenas, they may become increasingly vulnerable by their reliance on the market to meet all of their needs. I will return to this idea later.

One point of concern for people who play out their fantasies or develop relationships with others in SL is that many of these experiences would have dire consequences if enacted in RL. Consequently, people meet other people in SL and have intimate relationships which would be considered immoral for those who view it that way, or cheating for those who view a monogamous relation the norm, or dangerous for those who understand the vulnerabilities of RL sexual encounters (e.g., sexually transmitted diseases and pregnancy). Interestingly I have read news articles that claim people have become divorced over sexual affairs that occur in SL (Adams 2008), and concomitantly the US legal code does not define SL sex with prostitutes and escorts (who sometimes by the way use this money to pay for college or meet family needs in RL) as unlawful. But consider the reality of this. Scripted events such as love sequences and ao's are deeply embedded in RL sociocultural norms and standards for the ways in which avatars can and should behave within SL, and thus, have to be experienced somewhere in RL in order to elicit the social imagination for design. The possibility of becoming emotionally invested in these scripted events and ao's is highly plausible as one can imagine it to be, which often is premised on their RL experiences. Imagine the RL situations. Many people get emotionally connected in SL and some people I have talked with take their relationships outside of SL and became engaged in the RL experience, such as RL friendships, courting, sexual affairs, divorce, social crime, and suicide. These people were the result of becoming an idea, the power of mind over matter, and the repercussions of and vulnerabilities of engaging in SL, embodying virtues that cannot exist without mediating the thin boundary between SL/RL or the idea that becomes so powerful it permeates RL in a way that disturbs "the dichotomy." Once that happens, people gamble with real jobs, spouses, children and wellbeing.

The same is true of those who create environments or sims in SL. These environments have to be experienced somewhere in RL and subsequently the best aspects of, say tropical ecosystems, are represented in these sims (Fig. 15.4). Designers select the best sand for beaches, the least turbid blue water, crashing waves, rocks, palm tree varieties, ferns, flowering plants, hummingbirds, butterflies, and romanticized cultural artifacts such as a pier, old row boat, hammock, sail boats, and so forth.

However, sweat and bugs in the eyes are not an option and neither is the hot tepid air that one feels when they visit the Cloud Forest in Monteverde, Costa Rica, for example. The uncertainty and chaos of the natural world is deemphasized and ignored, and fear is not present in the same way that it might be if one was really surfing in the ocean. For people who fear going into the ocean for a fear of sharks, the fear is hard to access. Where people may put themselves into situations where there is a fear of dying or becoming hurt, the same situations in SL do not create these feelings of apprehension, without spending hundreds of hours imaging them. There is fear however. It comes from being emotionally invested or learning what the consequences are from being emotionally connected with other SL avatars. When two minds connect, they connect in spirit, and there is some fear in doing that.

Fig. 15.4 Highly manicured and sterilized ecological environments in virtual reality

In *A Philosophy of Fear* (2008), Lars Svendson notes, "to see a horror film or play some terrifying computer game are safe ways of experiencing dangers" (p. 76). Art may be preferred to life. The function of art is to awaken, but at the same time, we are somewhat shielded from the injury and consequences of art. Svendson interprets art as a transactional medium whereby it becomes privileged space for experiencing a full ray of emotions that life can offer, without having to burden us with the consequences of what these emotions may be linked to within RL. He says, "the reason we seek out these experiences is, nevertheless, not that we believe they will help us master life but quite simply because they are productive in themselves." The idea is that fear can help to reaffirm, strengthen or challenge our ontology. He continues by highlighting what Edmund Burke noted, "that we find it satisfying to watch things that not only would we be able to get ourselves to carry out but would rather have seen carried out" (p. 78). The essential notion here is that fear creates a pleasure and excitement when it does not get too close, as very few of us would want to have experienced the Hurricane Katrina event firsthand, for example. Consider the following interpretation of Aristotle by Svendson:

> …Aristotle says that there is a favourable on the observer because he or she witnesses fearful impressions from a scene. What this effect consists of is not evident. It is possible to interpret Aristotle in such a way that we can say that we are dealing with a kind of emotional discharge in which the observer gets rid of inner tensions that it would otherwise be difficult to find expression for in society, and that ought to find such expression there too (pp. 87–88).

What Svendson is arguing here is that we can experience situations without putting ourselves in danger, while at the same time becoming emotionally invested enough that we may experience a wider range of emotions than accessible without severe danger or consequences in RL, but which are inseparable from our RL (also moral character development through ways we learn to deal with emotion).

He says, "we experience what could be called a fear by proxy, where another person – fictive or real – is in a terrifying situation, and we participate in this fear from a distance" (p. 88). We get to experience situations without any real danger, thereby gaining access to emotional elements not normally part of our actual lives. "One assumes two roles at the same time: in a sense, one is present in the narrative, film or computer game, but one also stands on the outside and can at any time remove oneself from the situation by closing a book or switching off the tv" (p. 89). The degree to which people in SL disguise themselves or develop virtual identities suggests that virtual reality serves as art-in-the-making for experiencing a spectrum of emotions more fully as part of being human and that this experience is desirable and what makes people yearn for being vulnerable. In this way, vulnerability is positive and analogous to art, where RL people are at the helm and control the level of emotional investment desired, where fear and other emotions are constantly lurking whether acknowledged or not, for those who operate outside of their RL values. But RL values, despite that they seem separate from designed avatars generate the fear, love, trust, and feelings of friendship that are shared with others online. As one person's profile says,

> 1 year ago I came to see—Read about SL in a Dean Koontz book—I had rules (so many rules)—Now I know there are no rules—none that I have kept—The game changes—The characters change—I change—There are people that have changed me, moved me, loved me, People that I love in return—We will never touch—never see each other—never feel the others breath but (always a but) you have changed me. If you wonder if this is to you **smiles softly** it is.

This profile statement is a good example of a person who embraces vulnerability.

There is an appropriate and significant vulnerability for individuals who do not reflect on the tension that exists between their experience in RL and experiences online—the ways in which these experiences could actually transform us. This idea is not unlike fear, however, which can be very transformative in our RL. After hours and hours in SL, I began to feel depressed when not in my avatar skin. At times when I finished spending more than 12 h online, I looked around at my real life and began to question what people's avatars might look like, why they did not make themselves more like avatars in RL, and why they moved so slowly. The analogy of a slowly loading internet connection and how frustrating that can be when one is used to a cable or satellite connection that loads quickly is appropriate here, with RL loading at the speed of a snail. Other people who have spent years in SL, who sometimes left their computers on constantly while doing other things too, have explained this similar feeling to me, using the term "laggy" to describe their RL. (Laggy is a term used in SL to describe when things load slowly.) Others said how SL offers stimulation and the possibility of interacting with others in a very stimulating way, across national boundaries, oceans, and cultures. For some people, RL is so boring that they spend aching hour upon hour in SL, they loose sleep, eat very little, stop exercising, and may become very unhealthy. They may take pills to deal with their increasing anxiety, depression, or obesity. Others neglect their children, forget to feed them lunch or also neglect family pets. These things happened to me while I was engaging in this research experience, albeit not in the way that I have read about parents who neglected an infant to death.

Consider the following profile:

> I'll never understand how people say that SL and RL are different. Even though the images you see here are pix-elated and fake, the human behind the keyboard is real, with real feeling, wants, desires, dreams!!

While this understanding of vulnerability appears more reflective, take for example, the hours of time that it took to create my avatar Bret, develop friendship relationships, and explore stimulating networks of sims that comprise SL. My experiences do not even scratch the surface when compared to people who have been in SL for years. One of my friendships is with someone who uses SL as a hobby, spends hundreds of $US weekly to upgrade and maintain their five parcels, which includes houses, beach cabin, castle, and so forth. The time invested in constructing these icons in SL and the associated environments along with decorating many rooms and "outdoor" spaces can only be imagined in terms of thousands of hours of time. These hours of time take away from building significant relationships with people in the community, volunteering, growing a garden, raising children or animal care. Indeed that was the case for my friend with suffering relationships. What about participating in community and cultural events, hiking and camping, playing an instrument, learning intergenerational knowledge and passing on these skills? What about enjoying the seasons such as raking the leaves, building a snowman, swimming in a lake or travel to participate with other cultural events and traditions? How about observing one's eyes, shoulders, gestures, and bodily language in talk? Although with a proper balance these things can be integrated with effective time management, it was very difficult for me to do all the things I enjoy well, while engaging in the research experience for this chapter. I found myself compromising the things that matter most to me and can only imagine how difficult it would be to do a lot of RL things well if I had become more habituated or addicted to SL. My relationships with neighbors suffered, as I did not have the time to talk with them and continue to strengthen friendships that make me less reliant on the market. For example, how they have helped me learn to garden, farm, and fix my vehicle. While it was exciting to find new environments where birds, butterflies, and other flora and fauna were graphically sophisticated, and at times I became very excited when attending to the bird sounds I recognized from RL (e.g., chickadee) in SL, I found myself seldom hiking or spending the quality time outdoors that has fueled my love and passion for the environment for many years. I can only imagine what would happen if I become much more involved in my SL in the ways that people do in this virtual platform. Although my eldest son was home with me for the entirety of a holiday season (which is how I was able to do this research), I spent much of my time on the computer. So that he and I could spend time together I bought him SIMs (City, …) games for his Nintendo DS. Many times I found myself making excuses for the time I spent away from family, my animals, university colleagues and the Earth environments that I love so much.

Relationships with family, animals, colleagues, and nature are not even possible in SL without the trust and caring relations that make up interdependence. Most people on SL are very wary about trusting others. They want to build a wall, pretend they can be immune from virtual reality, separating their SL and RL ineptly. Noobs

are warned constantly about giving out too much information and this is not unlike in RL when parents warn their kids not to talk with strangers, even the older lady that comes up to say "hi" in the grocery store. This situation is not the norm everywhere. Where I live in the northwestern U.S., people are trusting and many times I have talked with complete strangers, smiled at one, or discussed something that brings laughter into both of our lives. But the norm is not to be too trusting or something "might happen" that will harm you. We all give advice to friends about moving too quickly into a relationship with love and affection to avoid getting harmed in an emotional or even physical way. In SL, people protect their identities, and for good reason, many are doing things they would not want people to know about in their RL, despite that these same people call SL a game. It logically follows that if SL were a game there would be no reason to wrestle with vulnerability, because there are many games such as World of Warcraft, Grand Theft Auto, and others where people steal, murder, rape, and commit other crimes. The people who play these games clearly do not question whether it is "wrong," or if they think it is wrong, they engage in these games because of the excitement. In SL, very few people would answer my question of whether they think it is wrong to have sexual relationships if they have RL partners. Many people say they think it is unethical, but then also told me they engaged in role-playing where they kill. In RL, the ideas of cheating and killing seem to bridge the same moral questions. Some said they had relationships in both RL and SL, but of course, the relations in SL are superficial without the trust and love that goes into developing a relation—these people still do not share their personal information or trust the other in a way that one would if they really loved and cared for someone. Or if they did, it became clear that their relationship permeated RL and they acknowledged their vulnerability to the experience of RL encounters as well. Some even claimed that their significant other did not mind the SL relationships, which seems to challenge the normal psyche when a relationship is monogamous. Perhaps the partner does not understand the possibility of developing emotions, but then there are news reports where spouses walk in on their partners and stop it. One can find numerous YouTube videos and news articles supporting the feelings of betrayal and anger a spouse experiences when they find the other in a SL affair.

Consider how difficult it would be to do anything in RL without trust. In most RL cases, people start by trusting others until that trust is compromised or the person proves that their trust is not authentic. But in SL, relationships do not start with trust but lack the trust inherent in an increasingly fearful world, where RL trust cannot be fostered until people begin to let down their fearful force field. The ways in which people want to protect their everyday lives, family, spouse, identity, or employment serve to verify the things people worry about when engaged in SL, for example, the possibility of being stalked or raped, child abduction, and so forth. But the reality of these things happening is very slim in the same way that not talking with strangers has led to fewer child abductions, which has declined significantly since 1970. Despite that, parents have more fear about kids playing outside than before (Louv 2008). In my profession, I cannot even imagine working with teachers without the air of trust, reciprocity of trust, and the ways in which students must trust me to

guide them. When faced with decisions of trust, for example, allowing me to see one's home in SL and their created environments, I had to risk trust first and often it was only because I shared my life to verify and build trust that my friend avatars would begin to trust me. But then they had to turn off their "security orb," which permits some and not others to access "places" in SL. With trust, they showed me the things they designed and created, and the environment they loved so much, and they talked about their aspirations.

It could be objected that trust is something that takes time and relations in RL too and that many of the things I have explored in terms of trust apply to RL. I would agree that our society has become more fearful (Svendsen 2008). But is this the model we want to inadvertently perpetuate with virtual reality? A society like SL can be held together by fear, but as Svendsen argues, "fear has an undermining effect on trust, and when trust diminishes, the scope of fear increases. An increase in trust will also be the result of, and a cause of, a loss of trust," moreover, "a fear culture is no trust culture – and that has major consequences on how people relate to each other. Trust can be described as a 'social glue' that keeps human beings together" (p. 101). In SL, trust is deemphasized and ignored, and the consequence of a 'no trust' society will have serious implications in RL society and education. For example, psychological treatment for online addictions is already on the rise (Byun et al. 2009).

Without trust, how can one expect to ever rely on their neighbors for the integrity of individuals, communities, and the environments we live with in RL? Why would people share the knowledge that they have in confidence or have faith that it would be used in a way that would not hurt others or be used to help others? Why should elders in the community be consulted for what they know—customs and cultural traditions they carry forward from a time when these things reduced our reliance on the market and afforded a less monetary way of living? Why does it matter whether intergenerational knowledge and traditional skills are passed on to youth in our society? A capitalist society does not thrive on barter and trading, you do this for me and I will do this for you, or the crafts and handiworks of those who find a refuge in sharing their knowledge of how to grow vegetables, raising animals, caring for our individual and collective subjective well being, and how to relate with those who are less motivated by the machine, the computer, or the web. What about those who carve their refuge in the commons by knowing species and habitats, by endorsing the languages of their ancestors, words that have meanings for ways of treating others, responsibility and ethics of how to care and love Earth?

More than any other reason, people wrestle with vulnerability because of human touch and affection, where SL can only offer these things in imaginations. Earlier I noted the idea of mind over matter, but there is an objection just as valid of matter over mind. This idea is something most people eventually experience. As I write today, I visit SL much less frequently than before. I missed the embrace and the touch of RL, the feeling of love when two people create it together, the tongue of a pet that shows her affection on my face, and the temperature of the air. Why do people experience vulnerability, and why do they wrestle with this disorder of trying to separate internet life from their lived and breathed experiences? My suspicion is

that there is not enough to protect people from the vulnerabilities of digital technologies such as iPhones and other trendy technology out there now. It might be argued that these things are no different from those who get infatuated with their work life, books, farming, sports, and so forth. While it might be true that technology has many advantages in our lives and I have imagined the unique possibilities that SL could afford for the training of teachers in science education, I would still argue that the main point of this article is to show the vulnerabilities. These vulnerabilities are enhanced because many people assume that SL does not have a storyline, which makes it different from other interactive online games. But SL does have a storyline, which has been programmed by people with real values, and cannot be separated from the sociocultural experiences we amass through life. Whatever the motives of people engaged in SL, whether it be for attending school, finding love, role-playing ideas that draw on a wider range of emotions, or for the experiences gained when one puts themselves in a context very different from here, there is a storyline of vulnerability that people wrestle with when in virtual reality.

The Vulnerability of Virtuosity

As I experienced, people become sick and maintain unhealthy habits when they begin to get so embedded in virtual reality that they lose a normal healthy balance. At some point I thought becoming sick during my research experience had something to do with sitting for long hours, eating very little, and the energy expended. Now reflecting, it had more to do with a lack of human touch and real relationship development with the people I care about, my animals and farm, and the woods. I do not want to suggest my experience will be the experience of all people, yet there is an appropriate and significant vulnerability that needs to be addressed when working with teachers or any educators for that matter, in SL. The potential of using virtual reality platforms in science education will increase exponentially, but we need to study the possible vulnerabilities so that people can navigate the circumstances they find themselves traveling when embarked on virtual journeys. Virtuosity is sure to be one the most important aspects of engaging people in SL and the tensions they experience need to be a part of what it means to be educated. Consider how lives would be affected if pixels go away and people cannot log on. Science educators have an obligation to engage their students in the contexts of the environments where they are educated, not just the content included in policy.

Interestingly, we find ourselves reminded by the cornerstones of ecojustice philosophy—that SL and other virtual reality are part of the larger educational field, that language and learning are powerful mediums for passing on values and ideas, and that our very being is influenced by a chaotic and uncertain RL natural world. The tensions between our cultural needs, technological desires, and efficiency, and the larger systems that encompass these things, reproductive species and habitats, and so forth, are very much made for more than human experiences and relations. An understanding of ecojustice philosophy reminds us to attend to these things, as

they have influenced how cultural communities survived, adapted and reproduced within diverse Earth environments over thousands and thousands of years. There is much to be learned from the science of aboriginal groups and what they focused on often through subjective breathed and lived narratives passed over generations. These human and nature environments or ecologies cannot be captured by virtual reality, despite the efforts of those who wish to live exclusively within this space. In many ways, a world designed for humans by humans significantly limits viable reproductive potential and the learning necessary for longer-term sustainability. I suspect that there will be criticism to this last point, but perhaps it is only because we humans sometimes think and act like our real world was designed for humans, when in reality, virtual reality is the closest we can ever come to a designed world.

Appendix 1

SL = Second Life
TY = thank You
TYVM = Thank you very much
YW = Your welcome
TTL = talk to you later
Convo = conversation
Diff = different
LOL = laugh out loud
LMAO = laugh my ass off
ROTFLMAO = roll on the floor laughing my ass off
TC = Take care
SS = see you soon
NP = no problem
LTNS = Long time no see

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Chapter 16
Beyond the Actual: Exploring Constructs of Reality, Knowledge and Culture in Virtual Environments

Catherine Milne

A number of years ago we had the chance to run a Forum at which people were able to participate as actually present participants or as avatars embodied in the world of three dimensional objects in *Second Life*®, a ludic online virtual world run on Linden dollars (Ensslin and Muse 2011; Lindenlab n.d.). The use of the term, ludic, locates *Second Life*® in a playful virtual environment. Although, as Michael Mueller notes in his autobiographical chapter of learning to live in *Second Life*®, in a world populated by people, even a virtual one, the experience is not always playful. As a virtual context, *Second Life*® allows residents to co-create any space they may share. People are able to select an avatar that represents them in this virtual world. Donald Jones (2006) observes that although virtual worlds, like Second Life, free participants up to be whoever and whatever they like—that is, free from limits of factors such as geography, ethnicity, gender, sexual orientation and socioeconomic background, such freedom may be illusionary because this world manifests social and cultural constructions associated with its origins in the US. One outcome of this structure is that participant actions can serve to instantiate and promote the neo-liberal, capitalist, corporate ideologies that are incorporated by the developer of *Second Life*®, Linden Labs, into the structure of *Second Life*®. Also, the concept of a *Second Life*®, a virtual life, implies that there must also be a first life, an actual life. But as Jones notes, historically, human acceptance of what is real has undergone change from one era to the next. In this chapter, I explore our changing appreciation for what is real as we participate in virtual communities, virtual environments and virtual worlds and the implications that might have for how we come to know.

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According to the Oxford English Dictionary (OED online 2014), virtual means in *essence* not in actuality and comes to English originally from post-classical Latin. By its meaning and etymology we have a sense that to be "virtual" in virtual environments and communities is to contain essences of actual environments but not to be as real as the actual environments in which we live are real. Historically, this differentiation between "virtual" and "real" seems to have traction in cultures in which English is the language of communication.

What Is Real?

Throughout human history there has been ongoing discussion about whether our knowledge or our sense of what is real comes to us through our senses and our body's interaction with the world, which can be trusted if we clear our mind of distracting thoughts (Bacon 1620/1968), or from our minds because of how unreliable our senses are for informing our understanding of what is real (Plato 2000/1894). For example, while Aristotle (1910) was using his observations of the natural world, such as his observations of animals, to make claims about what was real, Plato was positioned with the metaphysical belief that sense perceptions were unreliable.

In more recent time, the development of the *camera obscura,* not only emphasized the value of our sense of sight but also placed questions about reality on a different basis—for what seemed to be reality, our image of the world, could be reconstructed and observed reflected, admittedly inverted, inside a box. The word, *camera obscura*, comes from Latin, camera – room and obscura – dark, although the principles of camera obscura technology had been known since 400BC and an operational version seems be associated with Ibn Ibn al-Haytham [Alhazen] (965–1039). According to Thomas Derry and Trevor Williams (1993/1961), the first illustration of a camera obscura was published by Reinerus Gemma-Frisius in 1545 (see Fig. 16.1).

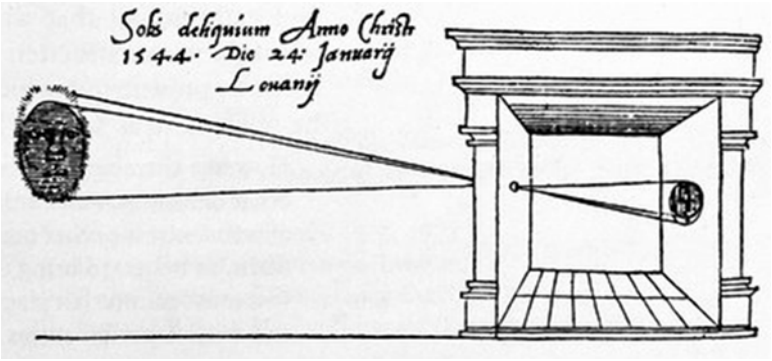


Fig. 16.1 Gemma-Frisius image of the camera obscura he used to observe the eclipse of the sun

With the emergence of empiricism in seventeenth century Europe, great attention was given to the use of the senses through the use of new technologies, such as microscopes, telescopes, barometers and thermometers, that gave humans the sense of seeing further and observing the natural world in ways that were not available to them previously. These technoscientific observations were accepted as real, especially if observations were endorsed by other (scientific) observers. Consider for example Anthony van Leeuwenhoek's 1676 request that a delegation from the Royal Society of London visit him to confirm his claim to have found tiny "animalcules," which are microscopic single-celled organisms which also were previously unknown, when looking through a microscope that he had made. These developments made observations of the natural world the basis of reality (Jones 2006), but the development of technologies that take us into a world that we can experience but not touch, smell or taste, raises the question of how we construct reality.

In a virtual world, how do we treat what is real? I want to explore this question, using a slightly different approach to that used by Carolyne Ali-Khan in her chapter, by thinking about the differences between the actual and the virtual as Gilles Deleuze (1994) differentiated them. He argued that both the actual and the virtual were "fully real" (p. 212). His claim that virtual was "real without being actual, ideal without being abstract, and symbolic without being fictional" (p. 208) captures some of the affordances and challenges of virtual contexts. Deleuze's description of virtual fits some of my experiences working with a team of researchers to build simulations of Kinetic Molecular Theory and associated concepts that can be used by students and teachers. Indeed the term, *simulation,* has similar meaning in both virtual and actual worlds. As I followed the 2014 FIFA World Cup there were debates about "simulation" on the field as forwards, seeking to score a goal for their team, "elaborated" their interactions with defenders from the other team. The goal of this "simulation" or "elaboration" was to be awarded a free kick or a penalty. In this soccer context, players and spectators have an expectation that the simulation is not "real" whereas people using virtual simulations understand that while a simulation is not "real" in the moment, it could potentially be real. Unlike the soccer field, in a simulated virtual context, participants interact with a simulation in order to have a vicarious experience of what it is like to observe and pseudo-experience, structures and resources not available to them in the actual world. For example, in our Molecules and Minds simulations students interacted with a particle model representing the behavior of gas particles (molecules) in a container. We do not claim that the particles are "real" and they are so abstract that students would be hard pressed to imagine they are anything more than a virtual representation. Our goal was to give the students an experience that supported them to visualize the particles that make up a gas and which are not currently available for observation.

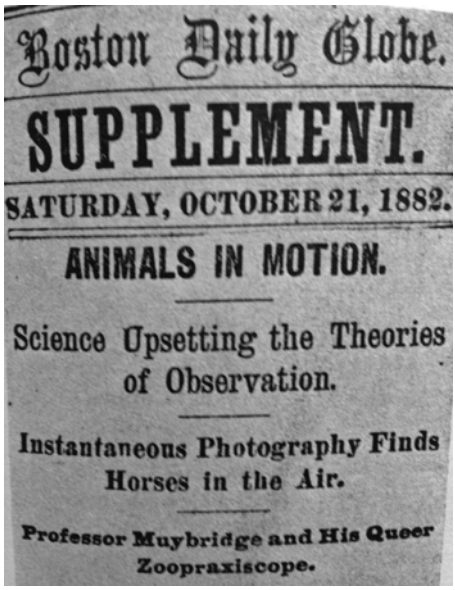
Simulations are polysemic and multifaceted. In virtual worlds, simulations sit on a continuum of virtual experiences from highly rule-governed massively multiplayer online role-playing games (MMORPGs), such as World of Warcraft, to more open contexts such as virtual communities/worlds, like Second Life and Active Worlds. Regardless of where they fit on the continuum, these different types of virtual environments constitute places where technology and humans come together. Grant

Kien (2009) applies Marshall McLuhan's (McLuhan and Zingrone 1995) notion of involvement, or the level of attention an environment demands of its participants, to describe virtual environments as electronic virtual spaces where "real experiences happen" (p. 12). If this description resonates with our virtual experiences, it also raises the question of how we come to understand space differently. There is no doubt that when I am playing *Bioshock* (2K Games 2007), a first person shooter game, I am caught up in the emotion and physicality of Rapture, the underwater environment where the game takes place as I explore various spaces within the environment. Kein argues that virtual space is just as physical a space as the space I physically occupy. The difference is perhaps that the virtual space is on a scale that, at the moment, we do not understand.

Of course, these arguments are not new. Walter Benjamin (1931) argued that technologies, such as the photographic and movie cameras, record aspects of reality that cannot be accounted for through natural optics. He wrote, "photography reveals in this material the physiognomic aspects of visual worlds which dwell in the smallest things, meaningful yet covert enough to find a hiding place in waking dreams, but which enlarged and capable of formulation, make the difference between technology and magic visible[.]" (p. 59). So although we rely on instruments to "reveal the truth" (Kein 2009, p. 12) about the world in which we live, we allow this to happen through our "optical unconsciousness" (Benjamin 1931, p. 59). Benjamin (1931) proposed the construct of *optical unconsciousness* to defend that new technologies allow us to become conscious of objects and experiences to which we were unconscious previously because of the limitations of the tools we use to explore reality. In this way, technology helps us to see and experience space and time differently. One of the most famous examples of this experience comes to us from the studies of animal motion conducted by Eadweard Muybridge (MacDonnell 1972). I would assume that many people have observed horses trotting or galloping but we lack the optical capacity, even if we try very hard to observe horse motion, to answer the question of whether a horse lifts all four feet off the ground when in motion. In 1872, Muybridge was hired by Leland Stanford to answer this question. At that time, he used the state of the art technology of photography to do so. His studies conducted in 1872 and then 1877 and 1878 used more effective shutter and chemical fixing that he had developed. At a press conference and demonstration, Muybridge was able to show both his photographs, which have become famous, and also demonstrate how the photographs were made by having a horse run through and trigger the cameras (MacDonnell 1972) (see Fig. 16.2 for evidence of the scope of his achievement).

What is interesting to me about this episode as reported by Kevin MacDonell (1972) is that the journalists who came out to observe the images generated by Muybridge and his technological marvel would not accept the veracity of the images, until the experiment was set up before their very eyes and the motion of the horses' hooves was used to trip the shutter. Muybridge says:

> Apparently some slight doubts remained in the minds of the more cynical journalists, but even they were convinced by what happened next. The Kentucky mare Sallie Gardner was brought out to gallop past the cameras. The previous arrangement of wheel-operated wires


Boston Daily Globe.

SUPPLEMENT.

SATURDAY, OCTOBER 21, 1882.

ANIMALS IN MOTION.

Science Upsetting the Theories of Observation.

Instantaneous Photography Finds Horses in the Air.

Professor Muybridge and His Queer Zoopraxiscope.

Fig. 16.2 Muybridge's achievement reported a continent away in Boston

> could not of course be used [because they would have injured the mare], so threads were stretched across the track that would operate the shutters as the mare broke them on her way past the cameras. She hesitated, the saddle girth snapped and she bounded forward. On developing the plates, every detail of the incident, even the broken girth, was shown and doubts were no longer possible (p. 24).

This account suggests to me a need of the photographers, not just to see the final product, but concomitantly to be participants in the production of the outcome, if you like to be active embodied observers. As Steven Shapin (1984) argues, even as experimental philosophy was developing in seventeenth century England, the goal of experimentation was not to obtain certainty of the observed world via demonstration and logic – which "compelled assent" – but instead to acknowledge the probability of physical knowledge removing "the distinction between 'knowledge' and 'opinion'" (p. 483). From this stance comes the notion of *matters of fact,* shared observations about which one could be 'morally certain.' In this situation, the presence and participation of witnesses suggests a way in which these matters of fact are confirmed through the embodiment of both the participant and that of the performer and the witnesses.

Now consider the virtual world. I sense ambivalence towards the construction of facts in virtual worlds in a similar way as aforementioned when compared with those we experience in the actual world. Aimee Roundtree (2014) contends that in the theoretical sciences, which depend on simulations, narrative and explanatory power and verisimilitude are more important than a traditional idea of scientific facts based on conformed observations of the natural world. She cites the example of how simulations by Z. Jane Wang and her team, which were constructed to

explain what human observers perceived but what human calculations were not able to show, namely, that bees with a relatively large body to their wingspan could actually fly. Roundtree says:

> Wang's team simulates bees in flight. Hers is touted as the first ever proof that bumblebees and similar insects produce sufficient lift to stay above the ground . . . Here, the intuitive nature of the simulation – that it confirms what the eye can see, despite what theories predict – lend the simulation more validity than theories (p. 25).

Despite this, Don Ihde (2002) explains that from a phenomenological perspective the knower is always embodied, never separated from what is to be known. However, as I noted this relationship with the body is not the traditional cognitivist way of conceptualizing the relationship between the knower and the known (Milne 2005). For example, Institutional Review Boards at Universities, which evaluate human harm associated with research proposals from an ethical perspective, use language that separates the knower from the known, thereby disembodying the knower and objectifying the knowing. Katherine Hayles (2002) acknowledges the challenges associated with both perspectives but argues that our focus should be on interaction or relation from which cultural constructs of "the body" and embodiment, which has both physiological and cultural elements, emerge. Indeed, there is a tendency in research on technology and humans to delimit the object, the technology, from the participants, the subjects (Sørensen 2009). But over time this artificial separation is more and more difficult to justify as participants and their technology become entangled and both the participants and the technology are changed as a result. However, if we consider embodiment of knower and known as the most appropriate description of how we come to know then it logically follows also that we value the knowing that can emerge from our interactions in virtual environments. Andy Clark (2003) in his book, *Natural Born Cyborgs,* talks of *cognitive hybridization* as cognitive technologies from speech and counting to moveable type and now access to virtual environments via technologies such as email, telepresence, virtual worlds and digital games act as tool extensions. Ihde (2000) calls technology, *epistemology engines,* arguing that technology, initially in the form of instruments and machines, rather than "raw nature" suggests the phenomenon. In other words, technology is integral to our construction of the reality in which we move. He argues that we learn about our embodiment in the world by being in the world and reflecting on how this is based on how the "world points back" (Ihde 2002, p. 69). I am wondering if technology also acts as *ontology engines* supporting us to think of the world in ways not imagined before we had access to new technology?

We learn our embodiment by being in the world as active participants. Our bodies also are associated with our perceived and embodied identity both in the actual and virtual worlds raising the question of how virtual environments and our use of associated technology perpetuate ideologies, hegemonies, values and beliefs of a culture.

Is Our Reality Vulnerable?

Historically, people have been challenged to identify what constitutes culture. Is it a defined world of beliefs and practices that belongs to a specific group of people or is it something else? As William Sewell (1999) notes in one definition, culture is assumed to be "isomorphic with society" or clearly identifiable with a societal subgroup (p. 39). If we accept this definition then culture is thought of as a bounded set of beliefs and practices allowing one culture to be compared with another. However, culture can also be thought of as a theoretical category of social life that must be abstracted from the "complex reality of human existence" (p. 39). Sewell argues that culture needs to be understood as a category of social life before it can be explored as a concrete entity of belief and practice. As a category of social life, culture has been theorized in a number of ways but Sewell describes two contrasting perspectives: culture as a system of symbols and meaning and culture as practice. Culture as a system of symbols and meanings has a long history which Sewell links to Talcott Parson's systems approach to culture that consists of language-like code which resists broad change while allowing local change. From this perspective, culture is systematic, coherent, logical and stable. The notion of culture as practice breaks with any consideration of culture as a system of symbols that is logical, coherent, static and uniform and instead defines culture as the sites of practice that are sources of power differences, intentional action, contradiction and change (Sewell 1999). Thus, culture supports interpretations like those of Ann Swidler (1986) who described practices metaphorically as a "tool kit" composed of resources that mediate social action (Werstch 1998). Culture is constituted of a "diverse collection of tools" that provide a means for the performance of specific actions (Sewell 1999, p. 46). Rather than seeing these different views of culture as diametrically opposed, Sewell argues that symbols and practice need each other if we are to understand culture in all its complexity.

Appreciating the interaction between symbol systems and practice in constituting culture brings with it an appreciation that while culture might seem like an abstraction, we experience and embody culture and its associated interactions with resources, space and time. In light of this understanding of culture, the question can be asked: what happens to a person when they are engaged with virtual contexts? While our embodiment changes all the time it also continues to exist and it could be argued to be a central element of what makes us human. So how does the clean efficiency of new technologies, like *Second Life®,* intersect with the messiness of human bodies? As Mike Mueller shows in his chapter, this question is more difficult than one might think. Ihde (2012) describes two technology narratives that may inform how researchers and participants think about technology. One subtext is that technology allows us to extend our limitations associated with being a living thing – that has needs and ages – providing us with powers beyond our wildest

dreams. The other subtext is how technology leads us to endanger the human species and the world in which humans live. After all, since Descartes much of science and science education has been focused on the mind and separating it from the body. If we look more deeply for theorizing with a focus on the body, we may decide that it is worthwhile to explore social movements such as transhumanism that seek to go beyond the body to a merger of humans and machines creating "a utopian discourse around computer technology as a way for humans to escape the body" (Lupton 1995, p. 100). In fact, Lupton describes how some supporters of this escape from the human body, this transhumanist position, see embodiment as *irrational*. She notes also, the virtual body has no need to eat, drink, urinate or defecate, so many of the functions and their associated challenges that we deal with in the actual world can be ignored in the virtual. In other words, in a virtual world, you are not required to engage in all those messy bodily functions with the possibility for something to go wrong.

On the other hand proponents of transhumanism, such as futurist Ray Kurzweil (2000), argue that the human body will recognize its obsolescence in relation to the capabilities of technology. Kurzweil's position seems to galvanize arguments against what was seen as overly optimistic visions of humans and their technological future. Although I do not wrestle with this position, my interest for this chapter is a question of whose technology captures the interest of science educators and also which we might take more seriously within the transhumanist vision. Writing at the emergence of virtual contexts, Sherry Turkle (1995) says that her experience working with people who had opportunities to develop different identities online indicated that, "the many manifestations of multiplicity on our culture, including the adoption of online personae, are contributing to a general reconsideration of traditional unitary notions of identity" (p. 260). Donna Haraway (1991) aligns with this position and notes that for virtual communities and virtual human bodies there is the potential of the virtual world to transcend stereotypes by merging boundaries. According to Richard Bartle (2004), people in virtual worlds tend to behave differently to the way they behave in the "real world" as if these new contexts open up possibilities for action. But by 2009 the optimistic hopes Turkle and Haraway espoused seemed to have remained possibilities at best as Rhonda Hammer and Douglas Kellner (2009) claim that, from a gender perspective, technology's virtual context is largely a man's world and will remain this way until the power differentials between different sexualities and genders are acknowledged and addressed. As I discussed previously in this chapter, one issue the virtual world does not preclude is embodiment, which is the capacity of virtual worlds to make participants feel as though their bodies are involved in the moment – even if that moment is constructed in a space that we do not really understand (Inde 2012). In a virtual world participants are involved in sensing that their bodies are in motion based on a particular point of view they have of the virtual world where they feel as though they are located. At the same time our actions are based on the values and beliefs we take with us into the virtual world. Even in a virtual environment, we cannot escape ourselves.

Culture and Knowledge Sharing

According to Sadie Plant (1996), all working cultures, be they machinic, based on machines and their powers (Pickering 1993) or organic, based on living things and their power, "share the fact that they work at all" (p. 206). In these shared cultural systems then, information is distributed throughout the system and permeate the virtual systems that offer the potential for communication, connectedness, and synergistic thinking that are not possible in the "actual" world. I am thinking of how the game, *Foldit* (Cooper et al. 2010), was used to support the solving of protein structures. Now, instead of information being stored in discrete spaces, it is available in cyberspace. Of course, because such development is emergent, in some respects it seems piecemeal and dispersed (Plant 1996). In such online and virtual environments, options are expanded, but institutions still work hard to retain control of some elements of knowing. While the CSSE Forum held at Drexel University incorporated *Second Life*®, recent years there has been a shift in educational contexts to other online media that were cheaper for universities and students and easier for institutions to control, such as Massive Open Online Courses (MOOCs) supported by social media such as Facebook, Twitter and a host of other social media developments (Baxter 2014).

Science education research seems surprisingly reticent about exploring questions related to how virtual environments challenge researchers and educators to a more nuanced understanding of both reality and culture. A search of science education journal databases reveals few publications that have explored these issues. Most studies that have been published examine learning of youth using simulations of various types. One exception is Darshandand Rhamdass' paper (2012) in which he explored the design and goals of an educational CSI game. Rhamdass, in his reflections on the learning from this game that claimed to engage students in the practices of forensic science, asked if there existed a tension between supporting students to learn the cultural knowledge of a discipline like science to become good at specific science practices and becoming good at game playing. He noted that there are some studies from science and medicine education that have shown the capacity of virtual environments to create spaces, both spatial and temporal, where learners are able to develop their skills and knowledge in a safe virtual environment. This brings us back to Kein's (2009) argument of whether virtual environments allow us to experience time and space differently even though we remain conscious of experiencing time and space.

While the question of how we understand the actual and the virtual differently and similarly remains an under-theorized/researched one, I think the virtual continues to provide us with epistemological-ontological engines that lead us to ask new questions and understand the world in ways that we may not imagine in the present. This is where uncertainty and ambiguity play an ever-increasing role in science education theory, research and practice—beyond positivism. Despite that *Second Life*® is no longer the excitement machine it once was, other forms of virtual environments and communities have emerged to interact with us in unpredictable ways. At the same time, I realize that virtual environments from simulations to worlds will always be imbued with the deep cultural biases and beliefs of those involved in design and development. How we interact with those environments and the questions they challenge us to ask cannot be predicted.

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Index

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