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Science in the Community:
An Ethnographic Account of Social Material Transformation

by

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A Dissertation Submitted in Partial Fulfillment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

In the Faculty of Education

We accept this dissertation as conforming
to the required standard

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ABSTRACT

This dissertation is about the learning and use of science at the level of local community. It is an ethnographic account, and its theoretical approach draws on actor-network theory as well as neo-Marxist practice theory and the related notion of situated cognition. This theoretical basis supports a work that focuses on the many heterogeneous transformations that materials and people undergo as science is used to help bring about social and political change in a quasi-rural community. The activities that science becomes involved in, and the hybrid formations as it encounters local issues are stressed. Learning and knowing as outcomes of community action are theorized. The dissertation links four major themes throughout its narrative: scientific literacy, representations, relationships and participatory democracy. These four themes are not treated in isolation. Different facets of their relation to each other are stressed in different chapters, each of which analyze different particular case studies. This dissertation argues for the conception of a local scientific praxis, one that is markedly different than the usual notion of science, yet is necessary for the uptake of scientific information into a community.

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This dissertation, is the result of work by this distributed actor-network and couldn't have happened without them.

Chapter 1: Foreword

I ask my readers to hear the explosion of this problem in every page of my books. Hiroshima remains the sole object of my philosophy. (Michel Serres, in Serres & Latour, 1990/1995, p. 15)

Every piece of writing emerges from a specific time and milieu. This dissertation has been written from a position amidst the struggles of the environmental and anti-globalization movements in the final years of the twentieth century. Although these topics are never explicitly treated, this thesis is in dialogue with many policies and positions related to globalization. In this foreword, I relate my position as a participant in these struggles to the intellectual work I have done in the rest of the thesis.

The first section of the foreword is entitled “Globalization and Democracy.” It is a short, inflammatory essay that presents many of the stories traded among Canadian activists at this time. The claims I make are not to be taken as thoroughly researched statements, although I have researched many of them. Their significance is that they are stories that are accepted and circulated within my community of peers: fellow grad students, leading academics, friends, roommates, public figures, on-line writers. These stories I tell are part of the taken-for-granted background to my life and the lives of many people whom I know. I include references to press, internet and other reports in order to support my claims about the content and tone of the narratives, rather than to prove some story or another is the way things actually are. I include this caveat because I am fully aware each and every one of the claims is merely a way of drawing attention to a very complex situation. My intent is to create atmosphere rather than scholarly accuracy.

This essay sets the stage for the second section of the foreword. “My Perspective.” The writings in this dissertation arise from a tension between my commitments as a scholar, my education as a scientist (a genetic engineer no less), my participation through the activist community, and indeed, my felt experiences of being a human at this time and place in history. Though the work presented in this dissertation is scholarly, it is also a response to the pull of many forces outside the scholarly realm. In the second section of the foreword, I suggest how the text of the dissertation fits into my

position within a greater community and history. Through it, I hope the reader can begin to hear some of the issues that explode throughout the pages of this dissertation.

Globalization and Democracy

My heart is heavy. Carlo Giuliani, a young protester in Genoa, protesting at a G8 summit, was shot dead. I just saw the photo sequence of his death today (FreeSpeech, 2001). Shot by a jittery young military recruit in the midst of a violent street protest. He is the first direct casualty from the “developed world” in the large-scale protests against the neo-liberal agenda that have been ongoing since those in Seattle against the World Trade Organization (WTO). Many others have died in the “Developing Nations” (Ainger, 2001).

Our leaders urge us to allow them, the democratically elected, to solve the world’s problems. The problem is, the leaders aren’t being democratic about it. They erect fences against their own people. They exclude meaningful public participation in the development of the trade agreements. These agreements are not only about trade, but have very direct consequences about governance, control of resources and so on. In denying these effects, our governments consistently lie to their own populace (Campbell, 2001; Dobbin, 2001; Gould, 2001; see Palast for a British example - Palast, 2001a).

The current president of the United States of America, George Bush Jr., cannot be considered to have been democratically elected. Recent evidence points to the elimination of approximately 20,000 Florida voters from the voter rolls, mainly African Americans, and perhaps up to 95% erroneously (the figure determined by checking a sample of the 20,000), by a private company hired by Jeb Bush’s (the president’s brother) government (Palast, 2001b). An analysis of the media recount in Florida shows that, using recount standards consistent with Florida law, Gore did win the election (Lukasiak, 2001). The data are showing more and more clearly that Bush bought and bullied his way to power, going so far as to turn an electoral loss into a victory. No statistical analysis performed by any academic predicts a Bush victory, or even a close contest (Kirsch, 2001). Legal commentators, both pro- and anti-Bush, cannot legitimize the decision by the Supreme Court that granted him victory.

In Canada, the federal and provincial governments are wilfully engaged in destructive combat with their own citizens. Eyewitness accounts reported in the alternative press and friends of mine all attested to the systematic and strategic violence that was inflicted on peaceful citizens by the police forces in Quebec during the FTAA summit this April (Rebick, 2001; see also rabble news, 2001). I have experienced these tactics and this violence personally during the Seattle protests. While in Seattle, I watched as completely innocent people were bludgeoned, pepper-sprayed and tear-gassed by the police. This type of activity went on, unresisted for hours, before any violence was expressed by the protestors. I experienced the intimidation of the police tactics and know the disproportionate degree to which the police mete out physical punishment. Their behaviour had nothing to do with keeping the peace and everything to do with instilling fear and provoking a backlash. This violence, for me, insinuates itself into my daily taken-for-granted experiences. I cannot pass by a “McDonald’s” restaurant or a “Gap” clothing store without thinking of the riot police that lurk behind Ronald McDonald’s smile or the happy kids dressed in pastel colours in the Gap posters.

The government, the conservative columnists, the World Bank, claim that they are attempting to help the poor. The problem is, they (the corporate government elite) created the poor in the first place. The world bank has criticized its own practices as contributing to world poverty (McQuaig, 2001b). Recent studies show the decline in standard of living for most citizens in countries affected by NAFTA (Campbell, 2001; McQuaig, 2001a; Weisbrot, Baker, Kraev & Chen, 2001).

Trade agreements like NAFTA curtail the powers of national governments, negating their ability to act in the interest of their citizens. Instead these powers are being ceded to trans-national trade tribunals.

The most recent variation on this scheme is the necessity clause embedded in the General Agreement on Trade in Services (GATS), which judges public policy decisions in light of the degree to which it inconveniences business. The tribunal has the right to overturn any law it deems “inefficient” with respect to international trade (Council of Canadians, 2001; Palast, 2001a). Unfortunately, what is efficient to international trade is often unwieldy to local governments (Palast, 2001a). And with the power to create an “Alice in Wonderland” world, where for example, bananas are considered a service

(Palast, 2001a), these tribunals act to impose heinous sanctions on nations' decisions to allow or disallow certain products into their countries. The cost of Europe's ban on hormone-treated beef, enacted on a topic, the potential toxicity of hormone residues in beef, that is not well scientifically articulated, is \$116 million dollars (Wallach & Sforza, 1999, p. 60). In effect, the WTO stripped European governments' right to decide what kind of product they wanted, and imposed a huge fine. This principle is much more insidious for small countries, who may not be able to afford losing hundreds of millions of dollars, and end up reversing public health, labour, or environmental measures.

I have read the trade agreements. I have seen the violence of the riot police first-hand. I have heard first hand accounts of what the working conditions are like in the developing world. To me, the trite sound bites about saving the world's poor, spoken by our dubious leaders as they exit their heavily palisaded fortresses, seem almost demonic.

We are becoming aware of and engaging in struggles on an unprecedented order of magnitude. Struggles against a totalizing politico-economic movement that is attempting to standardize, control, and commodify as much of this world as possible. This is not hyperbole. With the General Agreement on Trade in Services (GATS), in place, many taken-for-granted public services will be "liberalized," that is, opened up to foreign appropriation and control (Gould, 2001; Palast, 2001a).

I am worried about our nation's education being supplied by a hodgepodge of companies from America, which children's parents and our governments pay for. I don't want future students to have a "standard" education, designed in California, delivered on CD ROM. I am worried about health care being supplied by American insurance companies. I was recently told by a health practitioner that health insurance in Washington State runs over \$500 US a month. Their private health care is beyond my means; and it is beyond that of my friends. This is not a future for a country that has worked hard to take care of its people.

Science, in this corporate-government context, is appropriated to create, impose, naturalize and enforce categories. Attempts to standardize folk herbal remedies, attempts to standardize education, attempts to standardize food preparation technologies across the

world, attempts to standardize people through the rhetoric of genetic determinism¹, are just a few moments in this engagement. Reducing beings to genomes, reducing plants to chemical combinations, reducing people in environments to syndromes. This naming is essential to the creation of intellectual property, creating commodities that can be bought and sold, standardized, controlled.

Under the rubric of “intellectual property” things are labelled with no respect to their environment or contextual relations. Science, in this arena, is used to cut apart continuums, ignoring collective relations, creating isolation, creating categories, creating novel things only by virtue of naming them. That which was once a shared part of the experience of living is now made into private property, bought and sold. For example, a Texas-based company was recently given a patent for basmati rice (they had introduced a slight alteration into the strain) (Wallach and Sforza, 1999, pp. 108-112). India, now, is expected to enforce the patent over its farmers by collecting annual royalties from them or uprooting the crops. Altered, labelled, defined, controlled. Once they are isolated and named, it costs money to reconnect these beings into something whole. Indian farmers, cut from their heritage, from the work of their ancestors, under these rules, must pay a Texan company for the “privilege” to farm the rice their people developed.

“Science-based” regulations are also used to exclude non-scientists’ voices (Wynne, in press). My experience in consulting to the government about the regulation of genetically modified organisms bears this out. After twenty years of familiarity with the problems posed by genetically modified organisms, one of the questions they are still asking the public is: “Do you think that efforts should be placed on addressing [social and ethical] issues such as these?” (Canadian Biotechnology Advisory Committee, 2001, p. 28). The unspoken implication is that food is a technical, scientific enterprise and that scientists are the only ones able to competently speak about it.

¹ From the abstract of a wonderful multi-media presentation at the Society for the Social Studies of Science conference: “rather than assume that human genetic research left the problems of ‘ideological’ race behind with the adoption of ‘scientific’ population-based research, in this talk I contribute to the project of mapping the precise ways in which race continues to configure and be configured by contemporary human genetic variation research. Drawing upon ethnographic fieldwork at a leading biotechnology company in the American West, the talk maps the particular ways in which recruitment of human subjects, analysis of samples, corporate logics and the construction of scientific and social goals in contemporary human genetic variation research draw upon old and create new practices for constructing race: from anthropometry to self-identification to mass spectrometry.” (Reardon, 2000)

“Science-based” risk assessment trades off lives like monopoly money. John Graham, the candidate for the American administrator who has the choice to ban any new environmental protection agency (EPA) regulations, advocates the use of a system of risk analysis that borrows the notion of discounting future values from economics. In this case though, it is human lives which are discounted (Durbin, 2001).

The word “Science” is highly contentious. It is used as a claim used to buttress all types of rhetoric. In the hands of corporations, it has been used to silence critics, to block public investigation of alternative approaches to free-market solutions, and to marginalize people who articulate issues in emotive or cultural ways.

From My Perspective

I write my polemic not from outside science looking in, but from someone who has been inside science. I am so passionate about this issue because I love science. I wish it could be used to liberate, to work against those who would seek to do the ridiculous, sociopathic work of patenting a nation’s rice.

To me, science is about discovery. And about reliable narratives, told through a multitude of meaning-making systems: numerical, graphical, visual, physical. Science should support people in making decisions by providing the best stories possible, while fully cognizant of the limitations of the predictive value as well as the substantive content of these descriptions. A science education should be about passion, the passion of exploring and coming to understand relationships.

I want science education to support people’s active political engagement. I want it to provide them with the tools to understand not only the relationships of the elements to each other, but the relations of the funding bodies to the lobby groups to the PR firms and how those relations determine what we do and can know. I want science education to already engage, not prepare, students in exploration activity, in activity that matters to them and their life outside of school. I want children and students to have a chance to have their ideas tested, not by a curriculum delivery system or CD ROM, but by the actual materials or animals they are interacting with. To me, that is a science education worth supporting.

In my advocacy, I stand outside even my own community of environmentalists, however. I do not believe that the “correct” scientific understanding, free of bureaucratic bungling, personal interests and financial motives, will free us and protect the environment. I place no hope of some future clear understanding that will finally allow us to devise the perfectly sustainable policy, education or technology. I am convinced that knowing will always be entangled, partial, and contingent. It will always be an expression of its times and influenced by politics and finance. I do not place a high value on constructing a “nature” that is separate from and overarches humanity – that keeps creating categories and territories to defend and leads us to more and more hostility and frustration.

In my view, if we wait for true knowing to roll around, we will be waiting a long time. It is better to get involved and entangled, and stay open to the changes that will constantly sweep over us. This is learning. This is an education worth participating in.

This Piece

This dissertation is my way of participating. It is an attempt, among other things, to theorize the connectedness, the incompleteness, the pragmatic orientation of a science done in the spirit of empowering democracy within a representative democratic system. I do not attempt to make strange the commonplace in the activists’ daily doings, or bring out the tensions in their ambivalent stance toward science (Yearley, 1996). Instead I seek to make natural that which at first seems strange and marginal.

I seek to naturalize the technical, scientific, and political accomplishments of a tiny group, and by extension, of a way of doing science that is tangential to the usual institutionalized ways of doing it. I want to talk about a research site where nobody articulates their ambivalence and nobody discusses tensions toward science. Instead they do what it takes to get “good work” done. My activist friends build a reputation, they deliver on promises, they work against the “dinosaurs” who devise development schemes that do not take ecological issues into consideration. I want to create a narrative that allows their accomplishments in piecing together relationships that work in their community through modifying canonical scientific directives to come through as the usual, not the aberrant, way of going about things. By doing so, I hope to come to an

understanding of their action. I hope to come to an understanding of the possibilities that lay with science and learning science, as an emancipatory human activity, not one where anything but statistical indicators are considered invalid.

I feel there is a need for a new framework of learning what science is and what it can do. There is a need to express the absolute necessity of human relationships to the practice of knowing. There is a need to use scientific activity to inform, but not dominate public debate. This dissertation participates in this political project. It participates by attempting to make the typical science-related practices of the activists cogent and coherent. My goal is not to valorize them but to make their practices available for discussion.

I articulate a type of science done by people intent on learning about their home and about ameliorating their lifestyles to what the land needs. They are committed to developing informed and inclusive relationships (both with the people of the community whom they attempt to educate and to learn from) and with the ground water, creek, aquifers, ditches and bogs they hope to be able to restore to their proper “functioning” in an ecosystem. Science is done through culture and community. Community emerges through science.

To the degree that I am affected by the stories of my community, this dissertation is part of an upsurge that is already going on. It is a rallying of groups of people who have common goals. People are rallying to regain control of their right to have an impact on the political process. People are rallying to be able to know what is going on, accurately. And they are rallying to be able to influence important decisions that affect not only their lives, but those of others far away in space and in time.

Chapter 2: Introduction – A Theoretical Orientation

The purpose of this introduction is to ground the reader in the theoretical approach I have adopted for this dissertation. Because each chapter includes theoretical sections, my goal in this section is to make the reader familiar with the basic premises of the theoretical approach I adopt rather than provide an exhaustive literature review.

In section one, the major point of departure this dissertation takes from many others in the social sciences will be introduced. Section two describes the consequences of this departure, in terms of the methodological approach, theoretical concerns and unique ontology¹ that unite this dissertation. These will be elaborated in terms of their relation to a dominant theoretical model in the field of Science and Technology Studies (STS), actor-network theory (ANT). ANT is a methodological and theoretical framework incorporating an interesting mix of a structural² semiotics framework appropriated for post-structuralist³ concerns, grounded in research practices of ethnomethodology, discourse and textual analysis (Brown and Capdevira, 1999; Callon, 1986; Callon & Latour, 1981; Haraway, 1992; Latour 1999a, 1999b; Law, 1999; Lenoir, 1994). Specialized terms used throughout the thesis will be discussed, and the theoretical ensemble thus described will be related to the intellectual thrust as well as the research methodology adopted for the study. Following will be a brief introduction to the two other strands of thought that also inform the research writing of this dissertation, the practice theorists' conception of *situated cognition* (Lave & Wenger, 1991) and Bakhtin's dialogic textual analysis (Bakhtin, 1986).

¹ 'Ontology' is a branch of philosophy concerned with issues of being. To say something has ontological implications is to suggest that this type of perspective shifts the way we understand how/who we are in the world. I use this term often in relationship with epistemological issues, which are more about how we come to know about the world.

² 'Structuralist' researchers attempt to uncover deep structures, or systems of regularity within their research subjects. This type of research has been applied to, for example cultures, people's minds, economies and linguistics.

³ 'Post-structuralist' approaches argue against the existence of abstract structures and instead focus their research on embodied, material and enacted phenomena. To them, the problem of regularity, and of being, can be addressed wholly through examining the phenomenal world. This type of research has been applied to history, psychology, science and culture.

1. Avoiding Recourse to Essences

Avoiding recourse to essences is the foundational intellectual step taken in this work, and though it sounds straightforward, it is actually very elusive to grasp in its deep resonances and implications about knowing and order. In short, it is the intellectual commitment to not attribute causal status to monolithic unobservable things, such as “society,” “personality,” “intelligence,” or “nature.” It is an intellectual commitment to tracing how these attributions are used, generated, reproduced and so on in everyday life (Foucault, 1978; Garfinkel & Sacks, 1969; Lave, 1988). This commitment directly challenges the notion of a world organized on structured, timeless principles (Bourdieu, 1990, book 1). Though it may sound like a rather trivial distinction, it has many ontological as well as epistemological implications. The second point necessary for clarification is that there is no implication that for example, people do not display certain recurring patterns of behavior in and across certain environments. But rather, the attribution of their behavior to an underlying structure that they possess, for example, their “personality” is problematized. Instead, research attention is focussed on how the individual and others around him/her attribute qualities to that person, and by doing so construct a “personality”. As a researcher, I work to notice how and when the term “personality” turns up in conversation, what sort of actions reinforce what is said and how a personality is constructed out of an individual’s ongoing engagement with their lifeworld.

I use a personal example to help illustrate this point of departure and how significantly different it is from many approaches currently in use.

I was preparing a seminar to give to a number of faculty and graduate students, who were all involved in an interdisciplinary project. The topic was interdisciplinarity. To me, it made sense to first ground our talk in the factors that create disciplines. I was anticipating that the audience would provide me with a multitude of rich detail on all the factors that combine to create disciplines, such as: different buildings distributed across campus, different tools that are used, the different machines whose languages we learn, granting agencies and their insistence on categorizing research, conferences, specialized

languages, hiring committees and so on. When I presented my question to the audience, my first respondent said “I think it all boils down to interest.”

This vignette provides an excellent opportunity to differentiate the research approach used in this dissertation from others and introduce a more in-depth exploration of the theoretical discourse pervading the dissertation. From my perspective, by saying disciplinarity is a result of a researcher’s interest, the respondent made two moves, very commonplace among researchers in education and other social science disciplines, that I attempt to avoid in this dissertation. The first move was to *reduce* a complex phenomenon to a single *causal* factor. Based on the respondent’s contribution, we can say “disciplinarity” is a consequence of a researcher’s interest. One factor causes it. The rest is tangential, stuff they have to do to pursue their interest. From the theoretical perspective taken in this dissertation, “disciplinarity” is instead considered a historically constructed category, reinforced daily through a myriad of observable phenomena. Without universities, for example, a researcher might still have interest, but they would be without a discipline.

The second move is to invoke a *transcendent* cause, in this case, the researcher’s interest. This invocation is an extremely common activity, both in academic circles and in everyday life. “Intelligence”, “personality”, “gender”, and so on are all transcendent categories that are commonly attributed to individuals. However, no one will ever be able to see the researcher’s interest, no one will ever touch it or experience it. From the theoretical perspective taken in this dissertation, we re-locate that attribution. We decenter it from a “property” of something or someone to an activity performed by or on an individual, always in a specific social and material setting (Garfinkel & Sacks, 1969; Foucault, 1977, pp. 27-30; Callon & Latour, 1981; McDermott, 1993). In the vignette discussed above, the word “interest” would be, from the theoretical perspective adopted in this dissertation, treated as a discursive entity, used in talk, to account for why a researcher may find themselves in one discipline or another (Garfinkel and Sacks, 1969). No more, no less. The talk is always situated in some interaction. From the theoretical perspective taken in this dissertation, discursive doings are constrained to their relevance and use in local circumstance and not taken to stand for something beyond those circumstances.

In summary, the dual move that was made by the respondent was to reduce a complex phenomenon to a transcendent, causal factor. In the research and theoretical project I have embarked on I attempt to avoid doing these moves. Next, I present three reasons why.

The first is shaped by the nature of the research question. I am working to articulate heterogeneity and complexity, so a reductive approach is not appropriate. I research and analyze communication between different groups of people who have their own idiosyncratic ways of being in the world. Focusing on what they do, what they say and how what they do and say plays out in terms of the results (that we document) they obtain, seems more fruitful an approach than attempting to attribute transcendent values or beliefs or other organizing entities to them.

The second is a research habit of mine, developed during my days as a biochemist. I am inclined, in my research practice, to stay close to the physical world, to work to demonstrate connections and arrangements, and to rely minimally on grand models and schemata that apply to no one particular case. This plays itself out in the social science world as a preference toward data collected through direct experience, and collecting personal, historical, textual and video evidence. It also plays itself out through my writing practice of staying close to the data, and not reducing them or abstracting from them to qualities or essences.

The third aspect is related to the political project outlined in the foreword. My political experience (and now academic reading) has demonstrated the inappropriate power given over to transcendent entities, at the expense of a deep examination of mediating circumstances. Although I recognize that creating categories is a necessary practice of simplifying and making sense of situations, I am alarmed at how quickly they become naturalized and presented as properties of those who find themselves conscripted by the categories. Whether it be classifying forests solely in terms of harvestable timber, people as depressive or political systems as left or right wing, these categories, once naturalized, often help construct and enforce power imbalances that denigrate the individual, be they bright kids or old growth trees, in terms of only that category. Bright kids can be moved around from university to university during their undergraduate years, for example, in the training proposal outlined by the biotechnology trade association.

Thus, the rest of their lives are erased, and Star (1991) contends “there is suffering” (p. 48), as their relationships, sense of place and its relation to identity all are disrupted by constant movement⁴. Categories thus naturalized can be also used as labels and justifications for, for example, gassing and beating individuals, such as people I know who have marched in Seattle and Quebec City. Categories such as “protestor” now carry considerable negative social capital in many social situations due to their deployment in the media.

In preparation for a more egalitarian sustainable future, it seems very important to be able to talk about differences without reducing them to one rubric, yet while still maintaining intelligibility. Thus my struggle to include heterogeneity, to articulate the “borderlands” (Haraway, 1992; Latour, 1999b, concl.; Law, 1999), where the personal, scientific, historic and local all come together, is a vital task. In the rest of this section, I present some attributes of a theoretical approach that takes this task to heart.

2. Situated Theories

I have incorporated a number of slightly different theoretical approaches into the chapters of this dissertation. I outline the features of them which are salient to my work in the following sections. Between and among the chapters, I have not been theoretically faithful, and have mixed and matched different aspects of the positions mentioned below. This is standard practice in the field of STS, where there are no hard and fast theoretical commitments, beside the one mentioned above (Law, 1999; Brown & Capdevila, 1999). I have used the different ways of writing research as they suit my differing research purposes. They all share a commitment, however, to articulating a situated knowing, a knowing that is deeply connected to being and insist on the importance of material transformation and the arrow of time in how they conceptualize knowledge and action.

⁴ She wrote this remark in the context of an essay concerned with the effects of widespread standardization, and attributed the suffering to the property of standard practices and entities, such as McDonalds, in “annihilating our personal experience” (Star, 1991, p. 48).

A. Actor-Network Theory

Actor-network theory (ANT), first developed by Callon and Latour (1981), is, among other things, an appropriation of a structuralist semiotics (Greimas, 1985, 1987) to the investigation of science and technology.

Greimas' semiotics do not treat meaning as something static, that can then be related to language. Rather, he proposed that meaning "is meaningful only if it is the transformation of a meaning already given: the production of meaning is consequently a signifying endowment with form [Mise en form] indifferent to whatever content it may be called on to transform. *Meaning, in the sense of the forming of meaning, can thus be defined as the possibility of the transformation of meaning*" (Greimas, 1987, x)⁵

I use this quote to make two important points. The first is, we can see how, from his focus on form over content, Greimas could then develop this central assumption into a complex structural program exploring the mechanisms through which meanings become developed and transformed in narratives⁶. The second is that this structuralist project was ignored by Latour and Callon, who focussed rather on one aspect of his semiotics: its conceptual tools used to describe the transformation of meaning. Actor-network theory is, then, a way to articulate the circulation and recombination of entities that engenders transformation – of meaning and of entities. "It is a theory that says by following circulations we can get more than by defining entities, essences or provinces" (Latour, 1999a, p. 20). Because ANT focuses on arrangements and movements, it works to describe in detail the material circumstances of scientific discovery and the social arrangements that support and shape those material circumstances. Thus the notion of

⁵ This quote is paraphrased by a commentator to mean "we can ignore the static or philosophical problem of meaning and its relationship to language, along with the infinite regress of metalanguages that seems to result whenever we try to isolate the meaning of a certain verbal complex, only to find ourselves producing yet another text in its place; and the reason we can ignore this problem is that the static moment of the apparent presence of meaning in a text is a mirage or an optical illusion. Meaning is never there in that sense, or rather it is an "always-already-given" (to borrow a different metalanguage) in the process of transformation into another meaning." (Jameson, in Greimas, 1987, p. x)

⁶ He wrote of the research task of developing a "typology of competent subjects (heroes or traitors), which in turn allows us to identify different narrative trajectories. The overdetermination of these various competent subjects by the modalities of *truth vs. falsehood* and of *secret vs. lie* multiplies by as much the number of actantial roles, diversifies the subjects' syntactic trajectories and... *allows us to calculate... the*

event or *performance* grounded in a particular research site is central to the theory. It is through an entities' participation and transformation in an event that meaning and indeed, being, arise (Mol & Mesman, 1996; de Laet & Mol, 2000).

From its semiotically derived perspective of shifting meaningful arrangements of entities springs a rather different view of the world, yet this model is very good at describing the activity of scientists and engineers. In the following paragraphs, I outline five key aspects of the theory that pertain to this dissertation. My goal is always to ground the reader not only in the theoretical discourse, but also to note the advantage it gives the analyst, and why I considered it a pragmatic choice for my research writing. Once this list is completed, I introduce two other important intellectual streams contributing to ANT, and then follow this discussion by introducing the two other major theoretical traditions, apart from ANT, from which I draw.

1. ANT posits a world where distinction between humans and non-humans in terms of their ability to act in the world is meaningless. Take the example of a hunter shooting a gun. Through an ANT analytic lens, the hunter, the gun, and the bullet all *share* the agency involved in the gun's successful firing (Latour, 1999b, pp. 176-180). Agency, the ability to effect action, is distributed among the different actors. Therefore ANT scholars use the words *actor* or *actant* to emphasize that those who may meaningfully act are not necessarily human. Humans are not privileged with an a priori access to agency: trains, scallops or executives can all be considered actors. This move, unusual in the social sciences, gives the scholar the permission to describe or analyze a certain situation in terms of the relations between people and the non-humans with whom they interact (Callon, 1986). Non-humans, such as new computer processors, can be said to direct the activity of scores of programmers, who struggle to write code that will perform with the new technology (Latour, 1996a, pp. 219-223). By describing events in this way, the reciprocity between material "artifacts" and humans during embodied activity is brought out in clear relief.

This type of sociology is useful to the goal of this dissertation because this dissertation is about a relationship between humans and non-humans, in this case, an

narrative transformations [italics mine] produced within the framework of a given program." (Greimas, 1987, p. 111).

environmental group, a community and a watershed. The group's goal is to modify the many different water-related practices of its community. This goal bridges the "natural" and the "social" worlds. Thus a theoretical perspective that enables the researcher to articulate meaningful interactions, transformations and arrangements that are both social and material is helpful. By flattening the difference between human and non-human and focussing rather on their mutually transforming relations, I am able to articulate how people learn in response to, about and while situated within their environment. If I am to avoid recourse to ideals, then I do well to densely articulate the embodied situation.

2. The first point introduced a landscape of humans and non-humans participating together in activity as collectives. This second point elaborates how, through scientific activity, people come to know about, transform and of course, be transformed by the non-humans they study. This is the ANT stance toward scientific research and discovery.

The starting point for this section is the re-assertion of the non-existence of a priori qualities, owned by things. Thus scientists are not said to "discover" that things have "qualities" (Latour, 1987, chap. 2). Rather, an actor gains qualities or competencies through undergoing tests, or trials. For example, polonium, a radioactive element, becomes known as radioactive through Marie Curie's experiments, which create the conditions for radioactivity to be articulated⁷. She does not uncover a radioactivity that was always there, waiting to be discovered, but rather articulates⁸ its existence, creating a series of tests that it undergoes, and measuring and recording (*inscribing*) its responses. Retrospectively, after the non-human has undergone its trials, qualities, such as "radioactivity" are then ascribed to it. By claiming this, ANT theorists are not saying that polonium the world over became radioactive the moment Marie Curie determined it, but rather, for us humans, polonium came to exist in and of the properties ascribed to it by Curie, through her experiments. Polonium needed to be transformed in particular ways, noticed by particular other non-humans (in this case a quartz electrometer measured the

⁷ See Latour, 1987, pp. 88-90.

⁸ *Articulate* here is used in a specialized way and indicates not only textual or verbal statements about things, but the linked, segmented relations possible between statements and entities (Haraway, 1992; Latour, 1999b). The second meaning of articulated, that of being segmented, is useful to draw on. To articulate means to a state of affairs where possibilities, potential relations, are related together. For example, our activists, when they survey the creek, articulate it – participate in relations between it and

effect its ionizing radiation had on the air), to gain its identity as polonium, the pure substance.

ANT scholars use this type of narrative structure to emphasize the constructed nature of scientific facts, and that while in the process of discovery, scientists do not know what it is that they are discovering. While researching something, taking recourse to “Nature” is of no help, they need to rely on their beakers, meters, reagents and so on to determine the new entity’s characteristics. The final point I want to make is that of course, the scientists are also transformed by their work with the substances. They may develop radiation sickness, they may become recognized for their achievement, which in turn may give them access to more money, better lab space and so on. Through staying close to their semiotic emphasis on shifting arrangements, ANT scholars create humans who are reciprocally transformed by their interactions with non-humans.

This approach to discovery yields two advantages in the interpretation of field work. The first is that it allows me to be very precise about how the activists “construct” a stream. I need to note the array of humans and non-humans involved, such as pencils, waterproof paper, surveyor’s sights, tape measures, and so on. Thus my research gives an accurate account of how a stream comes into being, for example, in and of an ecological assessment. This helps me understand what it is people do, and what they may learn as they go about doing it.

The second is that it allows us to non-problematically talk about heterogeneity. It re-locates the problem of, for example, pollution of a stream by agricultural chemicals from the “ignorant” farmer to a problem of the assembly of humans and non-humans involved in the practice of farming (Mol, 1999). When we look at the problem from that perspective, it makes sense that one outcome could be pollution of the creek, because there are no ways for the farmer to measure pollution. For him, the pollution does not exist. Others need to do work, measuring oxygen levels or dissolved nitrates, to create the condition of “pollution” in the stream. We can then shift our attention from ascribing qualities to “the water”, as polluted, or “the farmer”, as ignorant, and focus on (for example) the different waters, one as measured by (for example) a dissolved oxygen

verbal statements, creek survey forms, remedial structures built in it, etc. The creek is now better articulated than it was before.

meter, and one as a non-problematic fluid in a ditch. By leaving absolutes, such as knowing the quality of the water, behind and putting our focus on practices of knowing, of articulation, we accomplish a major shift in approaching the problem. Our knowledge becomes linked to localities, situations and articulated relationships rather than ideals. This allows us to accept as non-problematic the existence of (for example) many waters in a creek – water as fish habitat, water as storm sewer effluent, water as irrigation, water as carrier of oxygen, water as purifying bath and so on.

Then the task shifts from arguing over the superior morality of one water over another and into a discussion/debate about harmonizing practices and priorities (Haraway, 1992; Latour, 1998; de Laet and Mol, 2000). It is a way of including multiple ways of interacting with the water, of being with the water, within a discussion of what to do with the water.

This shift suits the goal of this dissertation because this dissertation is concerned with learning that goes on between different communities of practice, about a certain resource, in this case water. I hope that this articulation will lead to more fruitful utilization of science in the resolution of disputes. By bringing to the foreground the practices of knowing, of transformation and of deleting, this perspectives shifts the focus from strident claims of rationality and scientificity to that of different uses and experiences. Thus it may be useful as a way to sidestep disputes about whose definition “beats” someone else’s definition, and put the argument in a more holistic context.

3. By paying attention to the arrangements and transformations of humans and non-humans that are involved in scientific practice, ANT relocates much of science’s “brain power” to the practice of generating and circulating text and *inscriptions*⁹ (Latour, 1986). Theoretically, this allows them to account for many of the achievements and much of the practice of science without taking recourse to causes like “raw intelligence” (Levitt, 1999, p. 4), capitalist economies, shifts in consciousness and so on (Latour, 1986). Rather, they emphasize that first and foremost, the practice of inscribing is ubiquitous at any site where science is practiced. Science, it seems, is the practice of transforming matter into signs on paper (Latour, 1999b, chap. 2). It is also pointed out

⁹ *Inscriptions* are non-textual meaningful entities such as graphs, blots, charts, tables, photographs, read-outs, scans, etc.

that inscription is a material transformation, for example, the transformation of a stream bed into a habitat quality chart on a piece of paper, is one that allows the inscription to become mobile and circulate without further transformation (Latour, 1986). Thus results obtained at one particular site can travel around the world, influencing activity on an international scale. This is true of circulating scientific journals just as it was true of the maps that allowed European navigators to consistently travel to countries which they colonized (Law, 1987), and the engineering sketches that facilitated the dismantling of artisan communities in eighteenth century France (Alder, 1998). As key actors in social and material arrangements involving, for example, such large-scale domination, inscriptions are granted powerful and central status in ANT. ANT theorists are not the only ones to focus their attention on the practices around scientific inscriptions. Many other STS scholars also make it their interest, from doing semiotic analysis of the figures and texts themselves to positioning the inscriptions in the ongoing activity of doing research, navigating, and bird watching (Hutchins, 1995a,b; Law & Fyfe, 1988; Lynch & Woolgar, 1990; Roth, 2001, pers. comm.; Roth & Bowen, in press).

This practice of paying attention to the generation and circulation of inscriptions and text by the activist group suits our situation because it is something that the activists ceaselessly do. Creek survey forms, water table readouts, stream bank cross sections, posters, maps, brochures were all produced during the time I did my field work. By following the pathways of some of these representations from the field to grant proposals to letters to council, I was able to discover the sites that the creek, as represented by the activists, traveled to, and was able to show how they transformed the creek to get different pedagogical work done in different locations. By following them (and being one of them), I was also able to understand where they went and what they did to learn and act effectively in the world.

4. The fourth part of science that ANT describes are the movements and transformations that inscriptions (and scientists!) undergo as they mobilize actors to bring about changes (Callon, 1986; Latour, 1996a). Here the transition from experiments to facts can be traced through multiple arrangements involving both the social and the material world. The trajectory, or path(s) taken by actors as they attempt to enroll the support of others to their project can be followed (Callon, 1986; Latour, 1996a). At each

site, often, the “natural” entities take on different guises, are presented as different things and do different work. For example, “water”, discussed with health officials, is a something containing certain amounts of fecal coliforms or certain ions and is measured relative to standard forms. It is something that is safe or not. For residents, it is a substance that kills their houseplants, corrodes their plumbing, something they have to drive to the gas station to purchase for drinking. The water is transformed as it moves from one social situation to another, as it moves from the resident’s home to the chemical laboratory, to the health officer’s desk, to the newspaper, it is involved in different arrangement, used to enroll the support of different types of actors. In the case of the water, residents hoped to gather enough allies (which will include non-humans such as fecal coliforms) to present a convincing case to the municipal authorities that action needed to be taken to supply them with a predictable supply of safe water (Callon & Latour, 1981).

This approach is useful for the research undertaken in this dissertation because we are concerned with the different ways people use science in the community. By following the trajectory of scientifically defined entities, I encountered the different locations in the community where these entities are handled. This allowed me to note the different uses to which the entities are put, and hence requirements and opportunities for learning. It allowed me to non-problematically encounter the educational, policy, research, “community outreach”, public persuasion contexts through which these entities pass. Because the approach assumes an open ended trajectory, it gives us a flexible big picture as opposed to one defined by a “system” with a set number of parts and pathways between them. And, importantly, it allows us to note how the entity is constructed differently at each site. Thus the advantages to this aspect of the theory overlaps with the second point made, about the relations inherent in an entity’s being. The distinction I make in this section is that we follow the entity, such as water, across the different sites where it is engaged and note the work of organizing other actors that it does.

5. This last point follows from the previous two. ANT scholars take as their ontology¹⁰ a thoroughly social and material world, made up of collectives of humans and

¹⁰ This use of ontology could be understood to mean “ground of being.”

non-humans mutually transforming each other over time. This is not the usual state of describing the social realm, especially in political arenas where the boundaries between what is considered “scientific”, as opposed to “political” or “value-based” are hotly contested and tightly controlled (Wynne, in press). ANT scholars contend that the creation of distinctions such as nature/society, subject/object are the outcome of a political project of appropriation of the power to define, by one group over another (Callon & Latour, 1981; Latour, 1997; Wynne, 1996). By erasing the contingencies and social process of scientific research, a politically privileged fact-based realm is set up, that of transcendent truth.¹¹ By allowing only a specialized few (scientists, engineers) to access it, a system where the greatest political project of all, agreeing on what is real in our world, is cut short, and many are forced to live in a world defined by the few. They argue for the creation of a radically inclusive democracy, where the many natures, produced by many cultures, exist in respectful coexistence (Latour, 1998, 1999b, concl).

Many STS scholars discuss the political implications of erasing the non-humans, claiming rational status, and naturalizing scientific results (Callon, 1986; Haraway, 1992; Law, 1994; Roth and McGinn, 1998; Star, 1991; Wynne, in press:). In the case of the research project of this dissertation, it provides valuable insights about how people use science to manage or politically prioritize heterogeneous accounts. The watershed in which the research is situated is a region that supports farming, suburban, industrial and First Nations relations to a creek. So an approach that allows a respectful examination of different ways of knowing and being with the water, with an eye to including as many ways as possible, seems appropriate.

These are the five major strands of ANT that run through this dissertation. To summarize, ANT is a theory of science and nature whose ontological baseline is the nature of the arrangement and activities of both humans and the non-humans they are interested in. “Nature”, “society” and so on exist in and of the observed qualities ascribed to them at the moment the scholar is observing them: they do not exist as entities onto themselves. There can be many natures, just as there can be many cultures, the distinction

¹¹ An example of this project at work today is the situation where governments and large companies struggle to limit the definitions of and labelling of genetically modified organisms, under the rhetoric of maintaining a superior, science-based system.

depends on the arrangements of actors that are brought into play into a certain articulation. Knowledge is located in the interaction between the inscriptions and instruments of the material world and the human scientists. The consequences of knowledge-producing activities can be determined by following the trajectories of the actors through time. And finally, an ideal society does not prematurely foreclose debate on what is real through the invocation of “scientific knowing,” but insists on the peaceable co-existence of as many well articulated natures and cultures as possible. A “scientific” fact must be able to stand up to a moral test, and likewise morality would be tested in terms of its relations to scientific knowledge.

Through my description, I have emphasized the foundational role that the semiotics of Greimas has played as an underpinning for this theoretical approach. But there are two other major strands of thought that influence ANT. The first is a type of sociology called ethnomethodology, and the second is the work of the French historian Michel Foucault.

1. Ethnomethodology is a type of sociology that not only implies a certain method, but also a certain focus or style of research writing. Ethnomethodologists are concerned with, as Garfinkel (1996, p.6) put it “to find, collect, specify, and make instructably observable the local endogenous production and natural accountability of ...society’s most ordinary organizational things in the world.” Along with the semioticians, ethnomethodology is interested in how meaningful things, like “knowledge” are performed in everyday life. From the ethnomethodologists ANT adopts a research program, a way of collecting data and a stance toward their research “subjects.”

ANT was simply another way of being faithful to the insights of ethnomethodology: actors know what they do and we have to learn from them not only what they do, but how and why they do it. It is us, the social scientists, who lack knowledge of what they do, and not they who are missing the explanation of why they are unwittingly manipulated by forces exterior to themselves and known to the social scientists’ gaze and methods. (Latour, 1999a, p. 19).

As this quote shows, the research program of ANT is to learn from those researched what they do and how they do it. They derive their analysis from *thick*

*descriptions*¹² (Geertz, 1973) of the sites being researched. Many major works in ANT involve detailed, often long-term work-site research (Callon, 1986; de Laet and Mol, 2000; Latour & Woolgar, 1979; Law, 1994). There is also a historical strain in ANT, but again, the writers tend to focus their attention on singular events, such as the development of marine navigation during a certain time period (Law, 1987) or the critical technical aspects of the space shuttle Challenger's demise (Vaughan, 1999). In general, actor-network theory draws its insights from analysis of detailed, focussed accounts.

To obtain this kind of data, the work typically involves participating at the work site to be studied, to one degree or another. While at the work site, data is collected in the form of copies of documents used (both mundane forms and more elaborate presentations), photographs, video, interviews and by learning procedures for working with the non-humans. The researcher, immersed in ongoing productive activities at the work site, takes copious detailed field notes. Another standard practice of ethnomethodology is to follow the information flow around an organization (Harper, 2000), so researchers also spend time finding out who talks (and doesn't) to whom, where memos go and what the results of these circulations are. They attempt to learn and make explicit the kind of knowledge required for an individual to be able to successfully navigate the world at that research site.

The stance toward the participants who are researched is summed up in the following:

In the particulars of his speech a speaker, in concert with others...is doing so over unknown contingencies in the actual occasions of interactions; and in so doing, the recognition that he is speaking and how he is speaking are specifically not matters for competent remarks.... ethnomethodological studies seek[ing] to describe members accounts...while abstaining from all judgements of their adequacy, value, importance, necessity, practicality, success or consequentiality (Garfinkel & Sacks, 1969, pp. 165, 166)

¹²In his book, "Thick Description: Toward an Interpretive Theory of Culture", Clifford Geertz also advocated a semiotic approach to interpreting ethnomethodological data, though not the semiotic approach described by Greimas.

Unlike many researchers, who attribute actors' actions to class, values, beliefs, psychological states and so on, the ethnomethodologically informed researcher asks the ones co-participating in the research what is going on and believes them. This is not to say that the same researcher would not consider any one of the above categories valid contributors to a certain situation, but rather would only consider it a valid player if informed of its importance by those doing the informing.

By adopting an ethnomethodological style, ANT researchers are able to obtain the kind of data that inform the detailed accounts that allow them to speak of shifting assemblages of humans and non-humans. The commitment to allowing the research subjects to define what is going on helps simplify the semiotic cast of characters (because the researcher does not add any) and supports their egalitarian vision.

2. The second other major influence or congruency is the work of Michel Foucault (Law, 1991). Foucault preceded the ANT theorists in emphasizing the importance of focussing analytically on relations enacted at local sites (Foucault, 1978, 1980). In his *History of Sexuality, vol. 1*, he described power as a set of enacted relations:

It seems to me that power must be understood in the first instance as the multiplicity of force relations immanent in the sphere in which they operate and which constitute their own organization: as the process which, through ceaseless struggles and confrontations, transforms, strengthens, or reverses them; as the support which these force relations find in one another, thus forming a chain or a system, or on the contrary, the disjunctions and contradictions which isolate them from one another.... Power's condition of possibility, ...must not be sought in the primary existence of a central point...it is the moving substrate of force relations which, by virtue of their inequality, constantly engender states of power, but the latter are always local and unstable. (Foucault, 1978, pp.92-93)

In this quote he is arguing that a social entity, power, is discovered through its operation, not flowing top down from a single site, but rather enacted through "ceaseless struggles and confrontations." It is not something singular, but moving, local, unstable. His work elaborating this analytic program of uncovering the local unstable relations constituting "power" has been very influential throughout the social sciences, and has shaped and supported the writing of the thinkers who work in ANT.

The other congruency he has with ANT scholars is a commitment to the importance of material relations in shaping human experience. He worked to describe how, for example, architecture influences power relations, by pointing out that by designing buildings in such a way that certain vantage points allowed one or two individuals a privileged view of the goings-on throughout the building, the architect was allowing the power relation abetted by surveillance – of workers, school children, or inmates – to be enacted. In the following quotation, he describes the effect of this design, the *panopticon*, in terms of power relations:

Each individual, in his place, is securely confined to a cell from which he is seen from the front by the supervisor; but the side walls prevent him from coming into contact with his companions.... The arrangement of his room, opposite the central tower, imposes on him an axial visibility; but the divisions of the ring, those separated cells, imply a lateral invisibility. And this invisibility is a guarantee of order. If the inmates are convicts, there is no danger of a plot, an attempt at collective escape, the planning of new crimes for the future.... if they are madmen there is no risk of their committing violence upon one another; if they are schoolchildren, there is no copying, no noise, no chatter, no waste of time..." (Foucault, 1977, pp. 200, 201).

Without a vantage point, a panopticon, those in charge could not enforce their rules or suppress the dissent of those who were in a subjugated position. Power, then, is literally constructed, and power relations are part of the design of the built environment. Many ANT writers have a similar concern with materiality's influence on territory often considered the uniquely human. Essays elaborating on the how notions like power and morality can be delegated to speed bumps and automatic seat belts (Callon & Latour, 1981, Latour, 1992, Latour, 1996b), work to spread the talk of notions such as moral agents into the non-human realm. Mol & Berg (1998) and Hennion & Gomart (1999) write of the blurred boundaries between inside and outside, human and non-human in both the medical fields and the arts respectively. Donna Haraway, with her articulation of cyborgs (Haraway, 1991) also delves deeply into the intimate relationship we have with non-human entities. Foucault's emphasis on the material, embodied and enacted nature of social relations resonates with and has informed many STS authors, particularly the actor-network theorists.

In the section above, actor-network theory has been described, both on its own terms and in relation to co-extensive schools of thought as a way of conceiving, doing and writing about research. It eschews recourse to transcendent essences and works to establish detailed accounts of how regularities and organizations are built, maintained, and transformed. It situates humanity within an ecology of non-humans which share in the practice of activities such as science with them. Human achievements and qualities are no longer considered to be the sole domain of humans, but are elaborated as the outcome of the work of collectives of humans and non-humans.

This theoretical approach has been adopted because it allows me to articulate the actual enacted doings of science in the community, between different sub-communities. It provides a way to non-problematically talk about heterogeneity. And it supports the educational goal of articulating a worthwhile scientific practice enacted at the community level.

In the following sections of this introduction, I introduce two other strands of thought that frame my writing about community science. I use them as alternative tools to approach the same theoretical goals as I have outlined above. I have used them because they concern areas of inquiry that ANT theorists have not yet elaborated upon. As I mentioned earlier, my theoretical project is pragmatic. I am interested in using whatever theoretical structure I can access to talk about embodied, situated knowledge, in all its complexity. I used the next two approaches because they helped me in that mission. In the field of situated theory, there are very loose boundaries, and the work of the following writers is considered part of the general discourse. By using these different theorists, I am using different branches from the same tree, not totally different approaches. But they are different in their lineage, in that they share Marxist and Russian roots.

B. Situated Cognition and the Practice Theorists

Practice theorists also seek to avoid recourse to timeless essences, and find their particular theoretical structure in the material dialectic, the interplay between the human and non-human, individual and culture. They share commonalities with actor-network theorists. They differ mainly in that they do not adopt an impersonal semiotic actor, whose identity is dependent solely on convergences of different entities. Instead take

recourse in the socially-located individual, whose agency is shaped by historical, material and social aspects (Engestrom, 1996; Lehenkari, 2000; Miettinen, 1998). A number of these theorists are concerned with learning and education, so I locate my approach to education in this camp.

Many practice theorists trace their intellectual roots to the work of Lev Vygotsky, a Russian doctor whose major works were done in the nineteen twenties. He worked to show both through experiments and philosophical argument, that cognitive development was mediated by tools and social factors (Vygotsky, 1978). He worked to break down the subject:object distinction and posit a mind that was dependent in its development not just on internal factors, but critically was always developing in the context of some social situation (Prawatt, 1999).

The two most important contributions of this theory to the intellectual work in this dissertation are the articulation of the situated (in a specific place), and distributed (among entities) nature of intelligence and the framework for learning as “changing participation in the culturally designed settings of everyday life.” (Lave, 1993, p.6)

1. Articulating the situated, distributed nature of learning and intelligence is a fundamental intellectual project for practice theorists. Jean Lave, a prominent practice theorist concerned with learning, critiqued the essentialist doctrines of cognitivist psychology (Lave, 1988). She pointed out the difficulty of erasing context from people’s doings. She provided persuasive evidence to suggest that people’s participation in the social situation of a psychology experiment was within a context that was different enough from their everyday lives to make the transfer of results from one arena, the lab, to the other, the world outside the lab, very problematic (Lave, 1988, pp 1-44). Through a review of cognitive psychology literature, she pointed out that the cognitive psychology community itself could not agree on the validity of transfer of experimental results about the cognition of “problem solving” from the lab to everyday world. In fact, from her accounts, analysis of the psychologists’ results suggest that it is indeed a problematic transfer (Lave, 1988, pp. 43, 44). She shows the basic premises of cognitive psychology to be inadequate to model a person thinking and doing in their usual, familiar environment (Lave, 1988, chap. 8).

Another major contributor to the field of situated cognition, Edwin Hutchins, approached the critique from a different angle. He pointed out that the major metaphor used in the information processing model of cognition, that of a computer, was fundamentally flawed (Hutchins, 1995a, chap. 9). Through a painstaking historical explication of the computer's invention, he demonstrated that the computer was a machine modeled, not on the human mind, but on a culturally developed, deeply material sociocultural practice of calculating. "The computer was not made in the image of the person. The computer was made in the image of the formal manipulations of abstract symbols" (Hutchins, 1995a, p. 363).

In his account of navigation practices on a naval ship, he shows how "mental processes" become built into the environment, and often become translated into people's physical manipulations of meaningful symbol systems. He argues that a much more satisfactory model of human consciousness lies in one that always locates the individual mind as part of a socially determined unit of cognitive activity (Hutchins, 1995a, chap. 3).

When we watch people in the process of doing tasks in their everyday environment, we cannot help but be struck by the extent to which functions commonly associated with the mind are performed by non-humans (Hutchins, 1995a,b). Lists serve as external memories. Architecture shapes our perception (Goodwin, 1995), and the design of objects such as calculators allows us to perform "mental" functions such as calculations, by manipulating those physical objects. People constantly refer back to their physical environment to orient their bodies and activities in space, to remember the sequence of events in doing a task and to express their ideas (Roth & Lawless, 2001, in press). Thus the unit of analysis in situated cognition is a different one than that of an individual information processing entity, a "mind in a vat" as Latour calls it (Latour, 199b). This way of conceptualizing learning is one that suits an actor-network research approach, as both emphasize the situated, embodied and mediated nature of cognition and activity. By adopting the situated cognition model, I can then extend my sociological framework into the realm of cognition.

2. The phrase *community of practice* is central to the discourse of situated cognition theorists. A community of practice is "a set of relations among persons.

activity, and world, over time and in relation with other tangential and overlapping communities of practice” (Lave & Wenger, 1991, p. 98). This community is a community of individuals engaged in activity. It does not imply “co-presence, a well-defined, identifiable group, or socially visible boundaries” (Lave & Wenger, 1991, p. 98). Rather it implies the people and things that participate together in an activity system. Lave & Wenger (1991) suggest that a good way to frame a community of practice for any one site is to notice how the community reproduces itself. Through the cycles of doing, promoting, and replacing people and things, analysts get an idea of the scope and membership of the community. All consideration about an individual’s activity and learning is embedded within the analyst’s understanding of the learner’s position in a community of practice.

Because it posits an individual always embedded in the ongoing activity of negotiating social and material activity, situated cognition model researchers find that

It is difficult, when looking closely at everyday activity...to avoid the conclusion that learning is ubiquitous in ongoing activity, though often unrecognized as such. Situated activity always involves changes in knowledge and action...and “changes in knowledge and action” are central to what we mean by “learning” (Lave, 1993, p. 5).

Situated cognition theorists work out research methodology and research writing practices that help them highlight the interactions between people socially located and embedded within their material environments. From this perspective, that of an embodied individual always immersed in social arrangements (whether others are present or not), learning takes on a different connotation. Rather than wondering whether or not a student learned the “content” of a curriculum, analysts are more likely to work to tease out the details of what performances the student has been involved in while engaged in the socially situated practice of going to school.

Many situated cognition researchers adopt a semiotic framework in order to help them tease out how individuals make situated meaning and coordinate between the different resources available to them in their environments (Lemke, 1999; Walkerdine, 1997; Whitson, 1997). Thus not only does a concern with the material basis of mind and

being link this approach to ANT, but workers in situated cognition to also draw upon semiotics in describing meaning making.

From this perspective, my role as an analyst interested in learning shifts. Instead of approaching people's practice from a deficit perspective, relegating their everyday activity to the background and wondering what, if any, content they took away from participating in science-related activities, I consider the successful navigation of a certain situation as their accomplishment. My questions change from "did they learn...?" to "what did they learn?" This shift in perspective has radically influenced my writing practice. I become reflective as I participate with others, and note the minutiae of what I learn as I participate and become sensitized to the ways that others mediate their relations. What counts as learning changes, and I can re-frame learning as always ongoing. This opens a window of analytic practice to someone writing educational research, from more straightforward, stilted accounts to ones that attempt to follow the wily, appropriate and inventive ways people enact to make their way through the world.

C. Bakhtin and the Utterance

The work of Mikhail Bakhtin informs the analysis in Chapter 10, "Monoglossia and Heteroglossia." He developed a style of literary analysis that was deeply rooted in the act of communication, or "speech communion" (Bakhtin, 1986, p. 62). He wrote polemics against structuralist analysis in linguistics and emphasized repeatedly that the transcendent language they invoke never exists. His notion of language was always situated in the everyday reality of life, was always embedded in an act of situated communication. Against the notion of a national language, he wrote "even languages of the day exist: one could say that today's and yesterday's socio-ideological and political "day" do not, in a certain sense, share the same language" (Bakhtin, 1981, p. 291). He argued that the complex influences on language, including time, task, culture, profession, gender and so on all were part of the actual use of language, which is the only time we ever experience it. Thus his analysis was focussed on the enacted, situated properties of language, unlike the rules and deep structures that structuralist thinkers like Greimas sought to uncover.

Utterances, the unit of discourse expressed in between changes of speaker, were the unit of meaning which Bakhtin analyzed. Unlike many linguistic theorists, his analysis of meaning was not just focussed on the words uttered, but included a consideration of the listener, acknowledging the profound effect that they have on what is spoken.

The utterance is filled with *dialogic overtones*, and they must be taken into account in order to understand fully the style of the utterance. After all, our thought itself...is born and shaped in the process of interaction and struggle with others' thought (Bakhtin, 1986, p. 92).

Thus his style of analysis is often termed *dialogic*. His analysis of meaning making is therefore also deeply relational, not appealing to rules of grammar or syntax, but to the action that the speech was and the action which accompanied it as it was uttered in the world.

I chose his style of textual analysis because it suited both the relational, situated theoretical framework I had been developing, and it suited the text I analyzed. Chapter 10 takes as its object of analysis the transcript of a public meeting, where a number of experts were joined in a debate by a number of residents of a municipality about the quality of their water. Bakhtin's emphasis on the social relations inherent in discourse provided me with a vocabulary to articulate social, political and material relations involved in the stories people were telling about water. In Chapter 10, I go more deeply into the theoretical foundations of the argument. Here, I mention only that it was an excellent framework for me to do textual analysis that emphasized the situated, relational and material aspects of the talk. His dialogic analysis allowed me to develop a text about a text while staying in the moment, and close to the actors.

Conclusion

All the approaches mentioned above center my writing in the moment of practice. This is the major pragmatic theoretical choice I make in the dissertation. For when the moment of practice is examined, the activities of the fisher wondering whether the half-inch mesh of his seine net is too big for the species he is trying to catch and the molecular biologist wondering whether a 1% solution of agarose is enough to differentiate the DNA

strands she is seeking to separate are not so different. I start at an undifferentiated present moment, with people attempting to get through a day surrounded by various assortments of humans and non-humans. From here, I can then follow what happens next, or what has happened before to make one knowledge local and less powerful, and another to be the only truth upon which major decisions are claimed to be made on. I attempt to free a moment from the a priori attributions of values, structures, culture and so on. I then note how these entities are added to the moment, through mechanisms of translation, talk, and movement. Then the work of untangling the useful, appropriate and relevant from that which stands in the way of a more realistic and healthy use of science in society and education can begin.

On Writing from a Critical Edge

Many of the chapters in this dissertation include critical comments about mainstream educational practices. It is not my intention to either claim that specific people or institutions are at fault, or that I think that “all of science education” is doing what I criticize. Nor do I think I am the only one who holds the opinions I do, or that there are not others, both within and outside mainstream education who have not grappled with the same issues and come up with similar answers. Or perhaps they have come up with different answers – all the better!

There are also times when I tell a story of a proposed practice as different from mainstream educational practice. This is especially the case in Chapter Eight. In this and other similar cases, I am not intending to critique at all, but am rather using difference to generate a narrative that allows a distinction to be made. I seek to make a distinction between what I guess might be common assumptions and the practices that I am advocating for.

I do, however, intend to clearly state those aspects of common educational practice that I consider counter productive in the education of an active, independent socially engaged science practitioner. I do this to problematize the issue with which I am dealing, to create space for discussion of alternatives.

Chapter 3: The Research Context

This study takes place in the Henderson Creek watershed and in Oceanside, the community that lies within this small coastal watershed in the Pacific Northwest (pseudonyms are used throughout this article for place names and individuals). Henderson Creek drains the north end of the watershed, Gordon Creek the south, and they meet in a valley, forming the main stem of Henderson Creek, which then flows west, into the Pacific Ocean. The watershed is located about twenty-five kilometres from the centre of a mid-sized city that continues to expand, pushing suburbia into the rural and agricultural landscapes.

The creek system within the watershed has been affected by human activity. There are small clusters of suburban development interspersed with the farmers' fields. Storm drains and ditches channel rainwater—along with the pollutants of suburbia, lawn chemicals and car leakage—into Henderson Creek and its tributaries and away from these newly developed areas. The municipality of Oceanside introduced an industrial park to the watershed, which is carefully contained within a four-block boundary. The drains of its machine shops and biotechnology labs empty into a ditch (affectionately called “stinky ditch”), which in turn, empties into Henderson Creek. To increase its potential to carry away water in a rapid manner, the creek itself has been deepened and straightened, and much of the covering vegetation has been removed, thereby increasing erosion and pollution from the surrounding farmers' fields. These physical changes have led to increased erosion and silt load in the wet winter months, and are responsible for low water levels and high water temperatures during the dry summer months when (legal and illegal) pumping for irrigation purposes taxes the creek. These and other factors have resulted in a drastic degradation of a once healthy creek and wetland system, and have played a part in damaging the inlet that borders Oceanside.

Despite the dismal state of the creek, a resident population of cutthroat trout persists in some of Henderson Creek's less disturbed reaches. From the perspective of restoration ecology, the creek is in critical but restorable condition.

The community's roots are rural. Farming continues to be the predominant land-use in the municipality. Oceanside hosts the oldest agricultural fair in British Columbia.

A thirty acre theme park, featuring working antique farm memorabilia, is operated solely on volunteer labour. The other major landowners tend to be wealthy individuals living on large two to ten acre 'rural residential' lots. As mentioned before, there is also an industrial park, which includes a gravel pit that is actively mined, and two villages whose combined population totals approximately 12,000. One village and part of the gravel pit are in the watershed.

The Henderson Creek Project

The Henderson Creek Project arose from the concerns of three watershed residents about water quality. The three, a farmer, a professor of environmental policy at the local university, and a stream biologist working at the Ocean Sciences Research Institute (OSR), obtained funding from a federal agency concerned with environmental restoration. They used this funding to hire a co-ordinator, Meaghan, an experienced environmental campaigner who is very familiar with political conflicts around water. Her experience includes international as well as local campaigns, and she is an accomplished writer and presenter of visual materials. Although she is familiar with the politics of environmentalism and media relations, she is not from the region, and her past credentials as a campaigner do not necessarily help her in interacting with the largely conservative community members. Usually, Meaghan does not mention her past in her present work in the community.

Meaghan is supported by a steering committee of about 5–7 volunteer members, who all live in the municipality. The steering committee meets weekly to discuss the events of the previous week and to plan future activities. Its members include: a retired civic engineer, an ecologist/local politician/farm products promoter, a water chemist, two retirees with experience in political campaigning and project management at the federal level, and a member of one of the less influential old families of the region who provides the activists with an important connection into daily community politics. The committee members are dedicated participants, but for the most part, are not known as major political players in the community, though the ex-councillor and the "old family" member know most of the community's politically influential members.

The Project enlists the support of many other people and institutions within the region to help get work done. OSR and provincial ministry scientists, university professors, local businesses, schools of every level, regional water quality technicians and hundreds of residents have also contributed time and resources to the Project's activities. Many donate one specialized skill or service, and become involved for the duration of a project. Students' participation is usually bounded by the terms of whatever educational institution they are enrolled in or the few months of a summer job. The Project's effective membership fluctuates, depending on who is helping out on which part of the Project at any one time. There are rarely more than 15 people actively engaged at any particular moment, and Meaghan is the connection between the volunteers who contribute several hours per week of their own time. The Project successfully solicits grants to hire students and buy supplies to enact stream restoration, community education, and scientific assessments.

The Project works toward restoring the watershed by bringing about change at a community level to support the health of the water bodies within and bordering Oceanside. Its members perform scientific research. They have built flow-monitoring stations throughout the watershed, and monitor seasonal changes in water flow in response to rain events. They have collaborated with the university and produced a Geographic Information Systems (GIS)¹ map that shows the extent of *impervious surfaces*² covering the watershed. They have surveyed a number of kilometres of the creek's length, measuring its physical dimensions and water and habitat quality.

The Henderson Creek Project is involved in more than just scientific analysis of the watershed. The Project does stream restoration work on publicly owned lands and endeavors to engage citizens in watershed stewardship agreements. It participates in outreach activities and its members give talks in schools, presentations at public events, and host open houses. They also participate in municipal politics, where they advocate for "stream friendly" policies. The Project recently won an award from an agency of the

¹GIS maps have special utility because they are graphical representations of a database containing many different features of a landscape. That is, they are many different maps, which can be layered by the computer one on top of each other, showing relationships between numerous factors.

provincial government for its “partnership approach to addressing stewardship, stream restoration and water management in the Henderson Creek watershed” (Meaghan, personal communication, 1999, July 28).

The Project has grown in the last two years. It has attracted more than \$200,000 in funding and in-kind support and has accomplished most of its stream restoration objectives at its first site. Current projects include refining a Geographical Information System (GIS) map of the community which details the extent to which the land is covered by impervious surfaces, developing a model for water movement through the watershed, drafting model bylaws that limit new paved surfaces, collaborating with the municipal government on developing water recycling, and lobbying for the construction of wetlands in areas that are currently farmed.

It is within this semi-rural municipality, working with this ambitious science-based NGO, helping to restore this particular watershed, that I have enacted my observer participant research project.

² Impervious surfaces refer to surfaces such as roads, sidewalks, roofs, and compacted earth that do not absorb water. The extent of impervious surface covering a watershed has a profound affect on streams’ health. Negative effects are noted at 12% impervious cover.

Chapter 4: Method Of Engagement

This study was mediated through my engagement with the Henderson Creek Watershed Restoration Project using a participant observer methodology (Denzin & Lincoln, 1998; Harper, 2000; Lincoln & Guba, 1985). This is a common choice of methodology in Science and Technology Studies (STS) research (Eisenhart, 1999; Epstein, 1997; Helford, 1999; Latour, 1999b, chap. 2), and is well suited to gathering both the first-hand experience and other documentation required for this type of research.

I studied learning and science in the community by volunteering with the Henderson Creek project. I was an active member of the Project for approximately one and a half years, from fall of 1998, to early summer of 2000. I did not fill any specific position within the project, but helped out where and when help was needed. I became familiar with the Project, its members and its activities through participating in the following activities.

I have attended steering committee meetings, assisted in organizing open houses, coordinated restoration activities, participated in creek restoration activities, co-written grant proposals, designed stewardship packages, advised on the subject of scientific strategy in an ongoing water use controversy and have acted as *de facto* Project coordinator while the regular coordinator took leave. I have helped move offices, dropped off film, taken photos for the Project's own documentation, scanned in photos, and made a stewardship presentation. I helped in making poster board materials for public events, attended open houses, public consultations, consulted with volunteer advisors about stream restoration and planting native plants, helped measure water flow levels, surveyed the creek bed, dropped off stewardship information to and met potential stewards. I coordinated the investigation of a fish kill, attended technical presentations given by Project members about the watershed, and have spoken at schools about the creek, the watershed and stewardship. Through these activities I have become familiar with the people of the Henderson Creek Project and how they go about accomplishing things. I have an idea of what they are trying to do. Acknowledging my contributions, the steering committee recently requested that I become a steering committee member, the only non-resident on the committee.

I also began research on a book representing the watershed, its history and environment and potential options for the future. This led me more deeply into the community, and I investigated its First Nations, geological, and pioneer history, as well as the current state of the environment, as described by a recent series of reports carried out by the Ministry of the Environment. My engagement with the Henderson Creek Project has also facilitated my familiarity with numerous other small, science-based NGOs in the region, either through their documentation, stories told or actual interviews. By the end of my research period, I was familiar with both the biophysical and the interpersonal features of the environment in which the activists acted.

The data I collected included extensive field notes, publications produced and appropriated by the activists, videotapes of public events, audio-taped interviews, newspaper clippings, informal interviews, and texts and inscriptions from the region that relate to the issues of watershed management and ecological restoration. On several occasions, I videotaped groups of activists and other interested local residents who walked sections of Henderson Creek with different consultants. The activists drew on these consultants for advice on how to improve the creek, how to find the best trout habitat, and how to expand the healthier sections of the creek. I also performed interviews with about 15 individuals linked to the project or living in the community about issues concerning the watershed.

These experiences and data were used as a springboard, a prompt, from which to write pieces for publication (Green, 1997). My choice of what to write about and how to write about it was informed by my reading in the field, what I learned by attending Society for the Social Studies of Science conferences, and through conversation with my academic advisor, Wolff-Michael Roth. Thus the writing arose out of interaction with a community of practice of which I was a new member.

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Chapter 6: Learning Science in the Community

This piece was written in the winter of 1998 and early 1999, within the first six months of my Ph.D. program. It was submitted as a chapter in a book entitled “Science as/for Social Action,” which will be published in 2001. Its intended audience is science educators who are interested in the potential of educational science activities to contribute toward positive change in a community.

The piece is grounded in practice theory of Bourdieu (1990), using his notions of embodied knowledge to scaffold a personal account of learning that occurs as one builds a scientifically-justified structure in a stream. Actor-network theory is also invoked both to emphasize the importance of relationships to a community-based project and to provide a critique of many of the science education practices that currently go on in schools. Gerard Fourez (1997), a Belgian philosopher also in the practice tradition, had written a piece published in “Social Studies of Science” listing nine recurrent activities that people engaged in scientific/technical practice did. His list was used to frame our contention that by doing work such as building in-stream structures in the community, science students were gaining authentic experience that would support their scientific literacy.

The data analyzed are field notes written after a day’s work with the activist group building an in-stream structure known as a riffle. These notes were used as evidence to support the claims that were made about the content of the experience at the riffle.

Thematic Issues

This is a piece primarily about scientific literacy. Current school practices are critiqued as being too strictly confined, both in terms of time and space and too concerned with classifying students as right or wrong. This critique created space to re-frame the grounds upon which scientific literacy could be considered. Both Bourdieu’s “Logic of Practice” (1990) and Fourez’s (1997) framework are used to show that what seems like just an everyday occurrence is actually a site where authentic science is being enacted.

The other theme strongly articulated is the importance of relationships. A large portion of the data presented spells out the multiple relationships that the activists become involved in during the course of one afternoon in the local park. It makes the point that this group is involved with many different individuals and adapts to people's differing needs and conceptions of the creek. It shows how a simple project like building a riffle is actually a complex event that brings together politics, history, and science in one spot. The data is given an actor-network style treatment (Latour, 1999a).

Representations play a minor role in this chapter. Interestingly, their treatment in much more detail in the following chapter is foreshadowed by the analysis presented in the current one. For example, the actual practice of building a riffle is related to the implied order and mathematical aspects of the riffle as presented in the design drawings. There are similarities between the analysis as presented in this chapter and what comes after, but the arguments are much less developed here.

Democracy and empowerment are never explicitly treated as such, though the overall purpose of the article is to begin to articulate a curriculum that does not attempt to dominate but instead to empower.

Learning Science in the Community

We live in a time when tremendous technological extension of human abilities and lifeworlds¹ is having a profound effect on our culture, neighborhoods and environment. Even with all this power available to them, many people remain on the outside of the technological riptide surging through society. Some science educators claim that this is evidence of a severe problem of technological and scientific illiteracy (Hazen & Trefil, 1991). Unless our students become scientifically literate, these educators say, they will have great obstacles to becoming empowered participatory citizens integrated meaningfully into society.

Although I agree that there is a societal problem of scientific and technological illiteracy, I take a different view of both the problem and potential solutions. Common examples used to “demonstrate” illiteracy fail to be convincing. For example, the film “A Private Universe” showed Harvard Ph.D. graduates who explained summer heat and winter cold in terms of the sun-earth distance rather than the inclination of the sun’s rays. In response to claims that this shows illiteracy, I reply that the inference is quite reasonable (it is valid for asteroids), and the fact that this interpretation is wrong in the context of the earth has little relevance to the graduates’ lives. Another standard example is the difficulty many people experience in appropriately programming a VCR. In this case the problem could be considered one of poor design or technical writing (Roth & McGinn, 1997).

I am more interested in how people do “science” than whether they can recite fragments of scientific discourse or interpret engineers’ technical inscriptions. When planning a meal, building a compost pile, taking a child for a nature walk, how does a person make sense of and act appropriately toward their biophysical surroundings?

The writing of the Belgian philosopher, Gerard Fourez, offers a different approach to science literacy. In an article on scientific and technological literacy (Fourez, 1997), Fourez outlines some of the major practices one may engage in through the

¹ The term “lifeworlds” refers to the entirety of lived experience, as a being in the world, and draws its conceptual basis from Heidegger’s phenomenology (Heidegger, 1977). For example, television news extends our lifeworld far beyond our everyday experience.

everyday use of science, whether as an environmental activist or an engineer. These frame his notion of scientific literacy, and include the skillful use of “experts; black boxes; simple interdisciplinary models (rationality islands); metaphors, comparisons and images; translations; standardized and disciplinary knowledge; and rationality in the process of making decisions” (Fourez, 1997, p. 903). Using these criteria for assessing literacy, I suggest that science is very different and much more than what is currently taught in schools.

This chapter explores the questions: What does “scientific literacy” look like? How does the experience of participating in an authentic science-related activity differ from that of learning science in school? and What is science? The analysis of a case study is scaffolded on Fourez’s notion of scientific literacy (Fourez, 1997), and Bourdieu’s *logic of practice* (Bourdieu, 1990).

In the rest of this introduction, I critique current educational practices, focussing on two problematic aspects of science education. To suggest an appropriate notion of scientific literacy, anthropologists’ findings of what techno-scientific professionals do at work are presented, and some of the common features of science in everyday life outside the work world are touched on.

School, Professional and Everyday Science

Is School Science Scientifically Literate?

[WMR - start] Over the past decade, science education as enacted in schools has come under criticism because of the constraints to meaningful learning it constructs (Tobin, 1990; Tobin & Gallagher, 1987). This line of argument is not pursued, although it is clear that little has changed since Tobin and his associates’ first qualitative research projects (Roth, Boutonné, McRobbie, & Lucas, 1999).[WMR - end] Here, I want to briefly address two issues seldom discussed, but significant in the context of our recent work. First, science and other subjects in schools are clearly demarcated into different domains spatially, in separate rooms, temporally, in time slots and cognitively into distinct subjects. Second, science encourages the production of a submissive populace.

striving to please an authoritarian figure, and discourages engaging in and challenging the current social political issues of the time.

Demarcations. In most schools, the main narratives of science are divided into units of subject area and within subjects, into groups of decontextualized “facts.” In everyday scientific endeavors these divisions are not so clear. Relations become more important as people gather together the appropriate tools (advice from an expert in another field or a new detection method) irrespective of discipline, to solve a problem. Facts become less important than the contexts, which argue for or against the acceptance of knowledge claims. What controls were run? What was the sample size? How was the variable measured? Who did the work? These are the issues practitioners consider when working with “facts.”

Schools also create boundaries between science and other aspects of society, such as economics, politics and history. Science is often taught as a sterile, disinterested pursuit of “perfect” knowledge. It is not uncommon to hear science teachers tell their students “That’s not science, that’s politics. Let’s keep out of politics.” This is not consistent with sociological studies of science and technology, which have repeatedly shown science to be interwoven in a constitutive way with other aspects of life (Haraway, 1992; Irwin & Smith, 1996; Latour, 1999b; Wynne, 1996).

The dissociation of school science from other school subjects is also embodied in the physical structures of school life. Beginning with middle school, students often move into specialized rooms (“laboratories”) where they enact particular practices said to develop their scientific skills. This physical separation demarcates science and associated practices. Laboratories become special places, with their special almost religious routines, their own forms of discourse, forms of adulation, etc. (Fuller, 1997; Noble, 1992). Although some everyday professional science is performed in laboratories, much everyday science is practiced outside their bounds—in offices, kitchens and backyards.

The temporal sequencing of the school day which tends to jerk children out of an activity before they can develop a coherent sense of it or a conceptual context before they understand it both contribute to an experience of alienation from the subject.² These short

2 [WMR] In several innovative curricula, it was shown how children build deep understandings in a variety of domains. These include simple machines (Roth, McGinn, Woszczyna, & Boutonné, 1999).

time slots are also experiences of time that are not consistent with those experienced while practicing science. Science tends to progress slowly. It is prolonged (it commonly takes researchers days or weeks to answer a simple “yes or no” type of question and up to years to address more complex issues) and cyclical. The same procedures are enacted over and over again, the same sites visited, or the same samples analyzed.

With so many boundaries separating science as taught from both other subjects and the practice of science (formally and informally) in the everyday world, it is little surprise that science is often not experienced as a subject relevant to students’ lives.

Creating a Compliant Populace. Many aspects of school science devalue the lifeworlds the students bring to it. School science is taught as if it trained future working scientists (Roth & McGinn, 1997). This focus is reflected in the systematic presentation of the detailed mechanics of theoretical constructs (“concepts,” “scientific process”). These are comprehensible and of interest to only a small number of students (as Eckert [1990] showed, mostly white middle class) and the “dress rehearsals” of routines of the lab where one is led through a standardized set of procedures. Little heed is paid to the fact that the very discursive forms and activity structures themselves are biased along the lines of traditional markers of difference such as gender, race and socio-economic status (Haraway, 1995; Roth & McGinn, 1998). This focus on scientists’ science unrelated to the children’s world effectively silences the students and encourages them to become disconnected from what they know.

Given that success and attendant rewards (marks, self confidence, career options) depend on the selection (grading) mechanism, it is not surprising that the motivation driving students’ learning of scientific minutiae is often to “get things right,” to please the teacher. In science classes, people are judged more certainly to be right or wrong than in other subjects, such as English or Philosophy where critical reasoning and original thought are given credit. This authoritarian emphasis on “getting it right” typically results in the average student agonizing over whether or not they can guess the expectations of

ecology (Roth & Bowen, 1995), or structural engineering (e.g., Roth, 1998). When students are empowered to explore phenomena over long periods of time, driven by their own interests and intents, students tend to show tremendous intellectual competency.

the instructor on exams and assignments, rather than being driven to explore an issue more deeply because of their passionate interest in it.

Even the practice of science through student labs becomes more of an effort by the student to “see” what they are expected to see and to do things the way they are supposed to be done (Roth, McRobbie, Lucas, & Boutonné, 1997) than an activity driven by their needs and curiosity. It becomes a ritual dress rehearsal rather than authentic practice (Bourdieu, 1990).

Finally, the system of rewards (marks) leads to a stratification to select appropriate individuals, which ultimately benefits only the “successful” (compliant) students and those institutions which train and employ scientists: industry, government and universities (Roth & McGinn, 1998). This symbolic violence excludes many students with interest and aptitude not measured by the regimented assessment system. It seems that both the subject matter and the method of instruction are not geared toward generating a scientifically literate populace, but rather function like a Fordian production line in a Foucauldian (disciplining) institution that forms employees of a certain class for a limited number of powerful institutions.

Laboratory Science, Science at Work

Over more than two decades, increasing numbers of ethnographic studies in scientific laboratories (and other similar environments) have shown science in a heretofore unknown perspective. Science as practiced is very different from the way it is presented in schools and through the traditional, objectivist history of science (e.g., Knorr-Cetina, 1990; Latour, 1999b; Law, 1994; Pickering, 1995). Accordingly, science as practice is very context dependent in both a local sense (tools, people, discourses, local practices) and in a global sense (politics, economics, funding cycles, societal problems). Many “facts,” to scientists, are understood to be dependent on many variables and reproducible under only the most controlled conditions. Rather than being self-evident, facts are often woven of strands selected carefully from complex webs of information.

The practice and experience of research is an activity well characterized by sociologists of science (e.g., Latour & Woolgar, 1986; Pickering, 1995). It is an active pursuit, typified by pursuing a question(s) of importance to the researcher. This practice

involves framing questions, engaging with technology in a purposeful way to answer (or engage) these questions, and creating and circulating artifacts. It also involves engaging in discourse to solidify the interpretation of the artifacts, creating inscriptions around the artifacts, presenting the intellectual nexus at conferences, and convincing others of both the importance and validity of knowledge claims. The construction of facts is seen as a complex phenomenon, where whom you convince with your data is just as important as producing “conclusive evidence.” In daily research practice, there is a high tolerance for and indeed an expectation that practitioners will make errors in the course of their work. Improvisation, both due to technical constraints and shifts in understanding the problem, is the norm. Scientists are professionals who need to be able to argue persuasively against opposition, act and think autonomously and take risks in their daily practice.

Science is also practiced at countless sites outside of laboratories. The fields of medicine, engineering, surveying, urban planning, law and marketing (among others) demand practices that use scientific techniques to examine the world at large and to justify appropriate actions. The boundaries between not only scientific disciplines but science and non-science blur at these sites (Fourez, 1997). Science becomes one of a range of (discursive, material) resources available to practitioners in order to solve a problem.

Science in Everyday Life

In our culture, science is given primacy to define the “essential world” (Latour, 1997). Unlike culture and politics, which are acknowledged to be the result of negotiation and to be constantly in flux, science promises us knowledge of a “real” world that stands beyond time and context. This timeless quality gives science a high position in our culture: it is called upon to provide instructions of how to do things and guidance on whether to do things. Even its linguistic register has become a powerful legitimizing rhetorical resource. Because of this, a great deal of political activity swirls around science—in many public debates the conflicting parties jostle for the right to claim science as their ally (Callon, 1986).

But the use of science in everyday life goes beyond the public debates. We all interact with science every time we wonder about the tests our doctor orders for us, or

whether or not we should buy a water filter, or whether we take our babies out in the sunshine and for how long. It is a tool we use to make sense of and guide us in our decisions about the world.

But the flow of information is not just in one direction, from science to the masses. Science is also formed and informed by “real world” factors. Its metaphors are those of the culture in which it is embedded (the computational metaphor of neuropsychology, the “blueprint” metaphor of the genetic code). The problems it tackles are determined largely by societal expectations (the Manhattan Project, AIDS research) or those of business (genetically modified plant seeds, CFC’s). The kind of and pace of information it produces is determined in part by public or private funding agencies whose largesse gives scientists access to the equipment they use (Epstein, 1995, 1997).

Activists straddle a unique place in the science world. They enact science, they depend on it to define their goals and justify their claims, they influence its direction through politics and the media (Eisenhart, 1998), and they work to involve citizens in its process and debates (Epstein, 1997; Helford, 1999). The practice of activism can be thought of as a confluence of many of the different streams of science-related activity.

In the remainder of this chapter, I provide a case study from my ethnographic research which tracks a suburban middle class environmental activist group (the “Project”) as they work toward improving the health of Henderson Creek and the watershed that feeds it. The group’s work is presented as an authentic everyday science-based activity. By examining the learning that goes on within the group, many aspects of learning that prove true to both the descriptions of scientists’ scientific practice and science as it is enacted in everyday life are teased out. Here people grapple with the issue of enacted scientific literacy as they use it rhetorically, to guide their physical actions, and to frame their understanding of the place in which they live.

Science in the Community

Project Proposal: An Undertaking Based in Science

The following narrative details and analyzes the activities involved in building an in-stream structure, similar to the “rapids” we encounter in streams, called a riffle. Riffles

are important in salmon streams because they add oxygen to the water and provide habitat for food eaten by salmonid fish. They are common structures that people place in streams in order to restore them.

Prior to building the riffle, the Project performed a surveying and sampling regime to map out the area they were interested in enhancing. The results of this research were presented in a document (the "Proposal," see Henderson Creek Project, 1998, September), which was part of a package submitted to the local municipality in order to secure permission to access Gordon Creek as it flows through Community Park.

This document includes color photos of the segments of the creek under contention, road maps, technical maps, aerial photographs, and tables of stream characteristics (i.e., dissolved oxygen levels at different points along the stream). The stream is described in terms of features such as length, slope, mean bankfull width, depth and width/depth ratio. Appendices listing the technical advisory committee—affiliates with the Pacific Geoscience Centre, Ministry of Environment, Lands and Parks, and the local university are included. The project has a strong association with Ocean Sciences Research Institute (OSR).

As they discuss different sections of the stream ("Reach 1, 2 and 3"), the linguistic resources drawn on are of technoscientific nature.

The lower 55 meters of this reach are relatively undisturbed, with vegetated banks, cobble- and gravel-dominated substrate, stable undercut banks, and 2 small pools ... The transition between Reach 2 and Reach 3 is marked by a decrease in slope from 2.6% to 1.7%, and increase in channel width, and a shift in bed composition from boulder, cobble and bedrock to sand, gravel, silt and cobble. The stream morphology becomes fairly straight and is composed of a 70 m long pool-riffle sequence downstream of the 16 m pool." (Proposal, p.17)

Here, the activists clearly use a scientific repertoire (genre, register) to make an argument for building the riffle. There are not just numbers and metric units (though Canada has converted to the metric system, much of everyday life is dominated by the imperial system), but some of these numbers include decimal notation. The creek does not just have a width but a "channel width," the creek is not just filled with rocks but there is a "bed composition" including boulders, cobble, bedrock, sand, gravel, and

cobble. Thus, in writing their proposal to the government agency and to the community leaders, the activists draw on a scientific repertoire. Whether or not they had “prior knowledge” of such repertoires, they knew that their proposal would be more convincing if it drew on the appropriate repertoire, and in the appropriate form. As part of their riffle-related activities, they enacted science both in the content (register) and argumentative form.

Why a Riffle? Why the Park?

Thus goes the riffle discourse: Riffles are stream sections characterized by steeper slopes, higher velocity, and shallower water depth. In stream restoration work they are structures made of stone which are essentially artificial rapids. Their major purpose is to dissipate the energy of the stream’s current, thereby reducing its potential to erode banks. They also serve to oxygenate the water; this increase is known to be good for two indicators of stream health, trout and benthic invertebrates. Thus, a riffle addresses a number of the key assessed issues³ facing Henderson Creek—it helps to reduce siltation both through acting as a silt trap and by reducing the energy of the stream’s current, which will reduce erosion of downstream banks, and it helps to oxygenate the water.⁴ They create pools upstream of the riffles that can be layered with spawning surface—sand and gravel, and thus provide crucial spawning habitat for the fish. With the goal of stream restoration in mind, putting riffles in Henderson Creek makes good scientific sense.

But where along the creek should a riffle be inserted? The Project’s steering committee chose the tributary of Henderson Creek, Gordon Creek, as it flowed through Community Park. Community Park is a local park of approximately 40 hectares, about half of which are wooded second growth stands of cedar, Douglas fir, hemlock, aspen and maple. As it runs through the park, the creek is protected by this over-story of vegetation, and for the most part, has sufficient bank-side vegetation to have stable banks.

³ Henderson Creek is beset with a variety of problems common to streams passing through twentieth-century humanized landscapes. There is high siltation due to erosion, flash flooding and drying out due to storm sewers, fecal contamination from horses and cattle, channelization, denuding of the banks, re-routing, burying, pollution from storm sewers and industry, etc.

⁴ Trout need relatively high levels of dissolved oxygen to survive.

Although “adult cutthroat trout have been noted through the park ... trapping through the park has failed to note a significant presence” (Proposal, p. 9). The park is directly upstream of the best cutthroat trout habitat in the entire stream system. This system is a stretch of about 1512 m of “natural, sinuous channel characterized by riffle-pool sequences, deep pools, stable undercut banks, overhanging vegetation, gravel beds, and habitat features such as large woody debris and boulders... Trapping and electroshocking through these reaches indicate cutthroat through all age classes” (Proposal, p. 7). If stream restoration could be performed successfully on the 600 m of stream that runs through the park, it would represent “a 34% increase in trout rearing, spawning and feeding habitat” (Proposal, p. 7). The fact that Gordon Creek in Community Park, with many of the conditions necessary for trout life, is contiguous with the best trout rearing habitat in the creek makes it an ideal location to begin restoration work.

As presented, this is a tightly woven scientific argument. In fact, trout and the need for a riffle mutually stabilize each other within the argument: Without trout, there is no need for a riffle, but the riffle creates and improves habitat for the trout.

Networks and Actors

But scientific validity was not the only aspect of the situation taken into consideration when choices were made about where to act on the stream. In the executive summary of the proposal, the site choice is justified by its “high public profile, its mix of public and private land ownership” (Proposal, 1998, p. 3). The riffle was part of a plan to generate a network of support for the stream enhancement project.

Community Park is very popular park. There are a number of playing fields with bleachers for spectators, a lawn bowling club and a treed picnic area included within its bounds. The trails through the wooded section of the park are well traveled—they are a common destination for dog walkers, and it is not unusual to see a horse galloping up the footpath in the ravine. Putting a riffle in Community Park would ensure two things: a large section of the community would notice it. And the park was well known and easily accessible, so people, learning about the riffle, could come down for a look. With the introduction of interpretative signs, extensive publicity for the project could be generated.

Five sites in Community Park were identified as appropriate sites for riffles (Proposal, p. 12). The site closest to the footbridge crossing the creek was the one that was chosen. It was closest to the optimal habitat downstream, but was also the most *visible* to passerbys. Putting the riffle at this site within Community Park brought challenges to the project. There is no single owner of the creek or adjacent lands. The municipality owns one side of the ravine, a series of landowners own the other bank, and the province controls the waterway. By choosing another location with single land ownership, the Project could have reduced the negotiation load.

The riffle is designed to create a deep pool behind it. This pool would have a mixed sand and gravel bottom, and would extend the trout's spawning habitat. The location of the planned pool was also the point at which horse owners train their horses to ford creeks—the bank's slope is shallow, the water is present and moving, but not enough to pose a hazard to the animal. So the riffle and the pool come into direct conflict with the interests of another community of practice.

These two factors were not treated as obstacles to a goal, but rather as opportunities to engage as many influential members of the community as possible. By gaining their support, the project increased its presence in the community through increasing the size of their network and the strength of its connections. By having the municipality on side, an actor representative of thousands of residents, they significantly increased the scope of their network and recruit a powerful ally. This was made clear when, as we finished work on the riffle, municipal workers brought and installed two interpretive signs near the entrance to the footpath next to the riffle—and the activists had not even requested them!

The homeowners living along the creek represent another kind of ally. Because they are considered "just plain folks" in the community, some of them descendants of pioneer families, their support has a strong effect on those residents who are not sympathetic to the municipal government. Also, by engaging landowners, the project again increases the number of actors in its network, stabilizing itself in the process. Since its long-term goal is to be a funding-free organization, this stabilization is crucial.

Meaghan, the project leader, sought to engage and persuade the horse community. A "horse person" herself, she would be considered an insider within the community, and

could draw on her own knowledge and familiarity of the community's culture to be an able negotiator. The issue of the ford crossing was not a pressing one for the riding community—it was perceived as an inconvenience rather than a big problem. By engaging the horse community rather than attempting to exclude them, the activists, with a minimal amount of conflict, enrolled another supporting actor and the people that made up its network.

Building the Riffle

Riffle construction is diagrammed by the Project using a cutaway view to highlight its different aspects—"crest," "gravel pad," "bedrock" etc. The riffle is diagrammed using triangles as if in a blueprint. The different slopes of the two sides could easily be measured and used to describe the structure—which is a triangle with its longest side on the bottom of the creek, its short, steep side upstream, and a longer side of more gradual slope on the downstream side. This description of the riffle is grounded in science and engineering practices. The experience of building the riffle was a different matter.

The light is gray. Breath swirls out from our mouths in clouds. The damp, if you're not moving, chills you underneath all your layers of clothing. It is still, the clouds hang limp and sodden, a low gray ceiling. Cedar and fir tower above us a hundred feet or more, leaning over the creek, forming a dark evergreen canopy above us. Green and gray, these are the colors of the Pacific Northwest. We toil, tiny, and try to keep dry and warm. [Fieldnotes, 10/98]

We built the riffle in layers of smooth cobble (no sharp edges to cut the fish), no less than 8 cm in diameter (palm width, no one used a ruler). After we placed a layer of rocks down, sand was used to fill in the spaces between them. Wobbling atop the slippery loose cobble, we wash the newly poured sand into the cracks with buckets half-full of stream water—careful not to get our gloves wet. It's too cold to get wet today. So washing the sand into the cracks takes a few pails filled with water. With every wash, silt erupts from the riffle in great tan plumes. It's too tricky to walk along the cobbles and get fresh water, so we draw water from the area we are washing. The water we wash with is dirty. I bend and twist as much as I can without losing my footing to reach cleaner water. [Fieldnotes, 10/98]

Here we glimpse some of the factors that inform our engagement with the riffle. Rather than angles and slopes, we have concerns of balance, keeping warm and dry, approximate “good enough” craftsmanship whose adequacy is not judged by a protractor or surveyor’s tool, but by a “feel.” “Looks good!” is the criteria. To judge the fitness of our efforts, we would step back and have a look—did the surface look smooth? When we stepped on them, were the cobbles firmly in place? Did our new layer of cobble present an even surface across the face of the riffle? After every few rocks we would step back and ask ourselves those questions. We answered them by feeling, using our intuitive riffle sense, and stepping literally on and pushing the riffle cobbles around in their riffle bed.

Sand is delivered in ice cream pails, which are handy but not ideally suited to the task at hand—they are liable to break if filled too full. The cold temperature outside affects the application of the sand—we sacrifice accuracy of pouring to keep our gloves dry and our hands warm. [Fieldnotes, 10/98]

By participating in this act of construction we move away from the authoritative certainty of mean bankfall width and slope and learn about a practical sense of placing cobbles and filling the interstices with sand and keeping balance.

We used the shovels to empty the pickup truck of its load of sand, creating piles on the ground, and then used the shovels to fill the ice cream buckets we used to carry the sand to the riffle. We also used first brooms then our booted feet to clean the sand out from between the ridges on the floor of the box (back of the pickup truck). Meaghan had in the box an 8 inch long galvanized nail, which she would run along the crack between the box and the tailgate to clear out the sand that had been packed in there. The tailgate wouldn’t close. Meaghan told me to just slam it, but it still wouldn’t latch on to the truck. I discovered that there were pebbles in the two indentations where the clamps, which clamped onto the body of the truck lay. Looking down on the ground, I found some small sticks and used them to extract pebbles the recess, which held the clamps. [Fieldnotes, 10/98]

In this case, multiple tools and strategies are necessary to close the pickup truck’s tailgate, a relatively simple task. Boots, shovels, nails and twigs were recruited to rid the truck of sand. Their use was highly context dependent—dependent on the progression of the job, where the sand was going and what space was being cleared.

Later in the day, I hung Florence's keys on her new broom. She had tossed her keys amongst the roots of a cedar tree, and with all the activity swirling around, I was worried that they might get covered up or that she would forget where she'd tossed them. I was also concerned that she might forget to take her new broom home, as it was just tossed off to the side, and she hadn't brought it (Meaghan had just purchased it to replace one crushed by boulders). By hanging the keys on the broom, the keys were off the ground and out of harm's way, and she wouldn't forget the broom. [Fieldnotes, 10/98]

In this vignette, the boundary between the mental and the physical worlds become fuzzy. The keys hanging on the broom could be thought to be doing mental work, that is, they are reminding Florence to not forget the broom and protecting the keys from getting accidentally covered by leaves or otherwise lost. These are skills we all use in practice, whether it be running an electrophoresis gel, or arranging the screws and nuts we remove from our bicycle when we fix it.

In much of these activities, we observe an enactment of *sens pratique* (practical sense, translated as *logic of practice*) which is characterized by a practical coherence that differs from the coherence of detemporalized, objectifying, scientific coherence:

Their unity and their regularities, and on the other, their fuzziness and their irregularities and even incoherences, which are both equally necessary, being inscribed in the logic of their genesis and functioning—to the fact that they are the product of practices that can fulfil their practical functions only in so far as they implement, in the practical state, principles that are not only coherent—that is, capable of generating practices that are both intrinsically coherent and compatible with the objective conditions—but also practical, in the sense of convenient, that is, easy to master and use, because they obey a 'poor' and economical logic, whereby no more logic is mobilized than is required by the needs of practice. (Bourdieu, 1990, p. 86–87)

Bourdieu criticizes "objective" theoretical constructs with their "forced synchronization of the successive, fictitious totalization, neutralization of functions, substitution of the system of products for the system of principles of production etc." (p. 86). Because of their conventions and structure (some of which are mentioned above), they lose their ability to describe how things are done. This problem is relevant to science

education because above all, science is an activity, though it is often presented as a collection of objective facts.

The experience of riffle building is shot through with this practical logic, whether it be placing cobbles where the riffle demands it, or the urgency to complete felt by the riffle builders as the day progressed, the light faded, and the participants got more and more chilled. This is important because it is the logic of not only life in the lab, but also of how things are done in daily practice. Washing dishes—rinse, or not, fill the sink, dry with towel or rack—or cooking a meal in the middle of a busy day—what is wilted, what is fresh, how much time is there left, what people have a hankering for. During the day's work on the riffle, I was continually challenged with situations which demanded his technical improvisation or judgement, and the feedback about the effectiveness of my choices was rapid and concrete (for example, did the pickup tailgate close?). Through engagement fraught with these challenges, students will learn about the art of doing, which is at the heart of science.

Through this intimate act of building and knowing, the participants learn about stream ecology. They see and hear the changes that the riffle makes in the stream. "Spawning habitat" also becomes a clear reflecting pool, "increased oxygenation and reduced stream energy" also becomes a delightful burbling brook, where once a silty trickle slouched towards the sea. Oxygenation becomes an aesthetic value, capable of binding people in a group.

The riffle had been working its magic, and overnight a pool had built up behind it; the water was probably about three feet in the deepest area. Certainly well above our gum boots. A creek I remember as a trickle⁵ (when I helped in the surveying) was now a lovely pond, cascading with a delightful gurgle over a bed of rocks. The creek seemed more alive than it had been. The sound of the water through the riffle was delightful, and we all reflected on how the riffle seemed to make the murky water clean and clear. The sound itself seemed to increase the stream's vitality. The deep clear pool was serene and somehow seemed fertile, now a rich spot for life (many lives) to spawn and thrive. [Fieldnotes, 10/98]

⁵ This section of the stream previous to the building of the riffle was a tiny trickle of a stream limping its way through barren black mudflats, a collage of rotted leaves and discarded twigs. Fine black silt from the winter floods had covered everything. Nothing grew. The black earthscape was punctuated only by the brilliance of the occasional beer can or potato chip bag.

Through the collective work, the members of the group learned to trust each other; and through our shared aesthetic satisfaction, reinforced by many visitors' comments, they came to regard each other in sort of a glowing light. I learned a little about Karen, a water technician, and her down-to-earth, "hands-on-working" values. I had fun playing within my happy relationship with Meaghan. I met and chatted with Florence, a woman whose sincerity, love of the land and personal industry I came to admire.

During the course of the day, many people came by to visit the riffle site and therefore became part of the network that stabilized the riffle within the community.

(1) A photographer from the Times-Columnist (local newspaper) visited. She spent about ten minutes of our time taking pictures of Karen (water technician) and myself picking up the rock, putting down the rock, talking to each other, picking up the rock, putting down the rock. We filled her in a little about what it was we were doing (necessary for the caption).

(2) Joe from Fisheries showed up. He had done a lot of stream restoration work, up on Rocky Creek in nearby Northtown. They had been working that creek for about 15 years, bringing back both salmon and trout. Joe had a look at the riffle and the riffle pool, and gave us some suggestions about improvement.

(3) Sam came by. He is a sole proprietor of a GIS/GPS company. Things are going a little slow in his business. He has volunteered to do the GIS mapping of the area.

(4) Michelle dropped by for a couple hours in the morning. She is the wife of a heavy equipment dealer/repairman. She lives nearby. She helped us out with the rock lifting. Her daughter Iris was also there, and stayed with us after her mom went home.

(5) Geoffrey came by. He is an old time resident of the peninsula, is in his seventies and though he walks with a cane, is alive and open and sprightly looking. He was telling all of us stories about the creek and the surrounding land.

(6) Berta dropped by for a few minutes, and spent about twenty minutes talking with Florence about the project. They were talking about councilors and civil bureaucrats and what was going on in local politics.

(7) Two young girls on horses trotted by as I hauled rocks into the wheelbarrow on the road. Signage had been placed on the road, indicating the creek improvement project—upon reading the sign, one of them said to me "does this mean we can go fishing in the

creek?” “Maybe” I enigmatically replied, and they galloped up the hill.

(8) Dogs loved the riffle pond. Every retriever who went for a walk that day jumped in. We could only hope we had made some good trout habitat, but we were sure we had created good dog habitat.

(9) Les, from the local newspaper dropped by. Karen and I posed for pictures, squatting in the pond.

(10) Alex also dropped by. He and I and Laurie surveyed the creek bottom a few weeks ago. He and Meaghan argued about some points regarding the riffle, some technicalities.

(11) Marta, 50-ish, came by and lifted rocks for an hour or so just before lunch. I think she just came by to help. Seems she lived nearby.

(12) In the afternoon, two steering committee members dropped by. Meaghan had neglected to inform them the regular meeting was cancelled. So they decided to have a look at the riffle which they had spent so many hours in planning.

(13) Two other guys (techy types) dropped by to check on the progress Meaghan spent 10-15 minutes discussing the riffle, pool, and plans with them.

(14) Another woman, whose name I forget, but who works at the nearby Federal Marine Research Institute in toxicology dropped by to see how things were going. We chatted about the lovely nature of lab jobs.

(15) Karen is a water technician hired by Oceanside farm. We shoveled sand/gravel out of the back of Meaghan’s pickup truck all morning. She left after lunch, around two o’clock. [Fieldnotes, 10/98]

In this passage we see the diversity of interests and connections to the stream and the riffle that converge on our construction project. The newspaper photographers are actors who can stand for hundreds of thousands of people. Three months later I am still reminded by acquaintances of my photo appearing in the daily paper.

Joe and the two unknown techies come by and spend close to half an hour discussing riffle particulars and probable consequences of certain actions: whether or not to in-fill under cut root caps. Are they likely to provide useful habitat, or will they likely be further eroded, and result in the loss of the tree? What would happen if we put a large log in the pool to reduce the force of the current as it approaches the riffle? Where would

the water be directed, what impact would it have on the surrounding banks? Through these informal exchanges we learn about the active riffle in the actual stream. They reassure us that the riffle is looking good and is doing what it should be doing.

We meet others who have been working on the Henderson Creek project and come to know them in a context where it is clear that I support the project, and this gives me common ground with them. This is important for me as a newcomer and helps my being accepted into the group. It is also fun. Because we are building something tangible, enacting our plans, finally doing something towards our long term goal of restoring the stream to “health,” the spirits are high, and there is lots of opportunity for storytelling and humor which bring us closer together. We met many members of the community and their encouragement and admiration and questions and interest helped me learn about the social environment within which I was participating. The stories told by the people who dropped by the riffle while going for a walk was an education in the community’s concerns and history.

The participant in such a situation learns about the community in which he or she is embedded, the history, priorities, mistakes, and conflicts that have happened and continue to happen over time. We get a sense of participation within a greater whole, a sense of knowing that cannot be separated from the accents, inflection and pacing of the conversations we hear and later carry on with others in the same locale. Rather than being some abstract concept, it is a process of absorbing the practices and concerns of a community at large, while having a definite place within the community (the creek restorationists) that helps to position us with respect to our conversations with others and lends us an identity. This is especially important for children, who are often seen as irrelevant in terms of contribution to the community, and may give them identity as active agents.

Meaghan told the story of how this riffle was achieved politically. First, she solicited support from DFO (Federal Department of Fisheries and Oceans), then MELP (provincial Ministry of Environment, Lands and Parks) through her contacts. She worked a lot with the people who owned the banks on one side of the creek and persuaded them to support the riffle. Then she presented council with the project and all the community support. It was

instantly approved on Monday, and here we are, finishing it on Friday.

But later, Meaghan told us the second half of the story. And that is that she did not have explicit approval from MELP. She was trying to float the application through on a rapid approval technicality “section 9” which is normally reserved for government projects. Although she was told her project would have no problem getting quick approval, the Ministry wouldn’t grant it, even by Tuesday evening. Meaghan wanted the riffle in very soon. (it was mid October) before the winter rains came and made the work impossible. So with all the volunteers ready to go on Wednesday, but without MELP approval, Meaghan decided to go for it anyway. She gambled (I am guessing it is bad to break provincial watercourse law), hoping her personal connection in MELP and technicality connection to DFO would combine to allow her to receive fast-track approval. Disregarding bureaucratic imperative, she forged ahead and began the work, only to find out a bureaucrat had misinterpreted her application—the bureaucrat thinking that the federal research institute was a private foundation, instead of a federal research institute. [Fieldnotes, 10/98]

Once again, the crucial role that networks play in enacting science is demonstrated. Both the informal network of residents Meaghan recruited and the structured network of provincial civil servants charged with regulating watercourses. Without Meaghan’s efforts at bringing residents “on board,” the riffle project would never have left the report and entered the Creek. At other sites, animal health, biosafety, hazardous waste, and other committees, limit what scientists can study—their world is also constrained by the demands of the bureaucracy. In this situation, the bureaucracy misfired, withholding approval, and putting the project at risk. Meaghan’s sense for the discourse of the regulations and regulators supported her in her decision to ignore the blockade set up.

Geoffrey, an old-time resident of the peninsula and the owner of a farm downstream from the park, was telling us stories. How people used to get up early before work, catch their limit of salmon by 8:01, and then head off to work. Now a salmon is rare sight in the inlet. He told us how there used to be schools and schools of herring churning the waters, but not anymore. We learned how there was a deep pool at this site, one where the children used to swim. The municipality had it filled in for safety reasons during the fifties. [Fieldnotes, 10/98]

Through storytelling, Geoffrey informed those present of the natural history of the region. These are the kinds of nature lessons that no textbook or video can give. We learn from someone while we are present in a space, about that space. We can ask questions about what we are interested in, or for more stories. We learn about the past, and this gives us ties, through our vision and ability, to the future. It engages us in the flow of time.

Geoffrey's stories instilled a deep sense of sadness and anger within me at how arrogantly, ignorantly and violently we had treated our natural surroundings. His stories strengthened my resolve to keep this restoration work going and to educate myself, to participate more fully, and thereby be able to educate others. Maybe one day my work would contribute to a return of some herring to the inlet, or maybe salmon.

In this chapter, the story of the riffle is bounded by the constraints of written publication. In the life of the community, there was no clear beginning to the riffle story (though we can always construct some criteria according to which we can define a beginning). The story really continues because the riffle has become part of the life of the community.

Is this Literacy?

Upon reading an early version of this paper, a colleague remarked that what we were describing was interesting, but why call it science education? This is an important question to answer considering that this experience looks very different from the one we are used to: students poring over textbooks, taking notes, doing simple experiments designed to demonstrate a concept like "pH." My analysis is scaffolded on Fourez's (1997) recent work on scientific/technical literacy. In it, he suggests that scientific literacy consists of the right use of a variety of scientific resources: specialists, black boxes, simple models, interdisciplinary models, metaphors, standardized scientific knowledge, translations, and knowledge and decisions. How many of his criteria did we fulfill that afternoon at the riffle? Could this activity be justifiably claimed as strong scientific literacy? What would legitimate peripheral participants learn on a day at the riffle?

Right use of specialists: From its inception, specialists' advice guided the project. Stream biologists advised and enacted the initial surveys, as mentioned in the case study. Joe gave important advice about what to do and referred Meaghan to another specialist, Cam, her co-worker. The project has had extensive support from its technical advising committee.

Right use of black boxes: This is the ability to judge when not to open a phenomenon up to analysis, but rather to just let it do its thing. That is, we do not need to know how a computer keyboard informs the CPU of the letters I am pushing. I am happy to use it as a black box. There were not many technological black boxes used in the riffle construction, as it did not rely on the use of high technology. But the empirical evidence, which resulted in the decision to build the riffle, could be considered a black box: as we did not question the need for a riffle, nor the theory that suggested what it would do for the habitat.

Right use of simple models: This is knowing when a situation needs to be explained theoretically for example "what model would be appropriate to work out when it is convenient to pull and when to push a wheelbarrow?" (Fourez, 1997) In this case, simple models about water flow and stream behavior were continuously modified as we discussed rock size to place in the riffle, effects of sand fill, where silt would accumulate, etc.

Right use of interdisciplinary models: This notion refers to "the invention within the context of a specific project, of an adequate model—fairly simple but using knowledge stemming from various disciplines as well as from the know how of everyday life" (Fourez, 1997). There was not much call for these types of models in the project, as the construction of the riffle did not require the expertise of specialists from different disciplines.

Right use of metaphors: Metaphors of relationship to land, of the nature of the stream and so on permeated the discussions all day long.

Right use of standardized knowledge (scientific disciplines): This means "inducting students into established views and methods that have been successful and without which it would be practically impossible to communicate within a scientific and technical society." (Fourez, 1997) The riffle itself and the justifications for building it

were embedded within the standardized knowledge of restoration ecology. In this case the standardized discourse was used “economically” (Bourdieu, 1990); we weren’t trying to learn ecology, we were learning enough to get the job done. The practice of ecological restoration is grounded in the Western scientific notions of prediction, control and experimentation. By participating with the group, enacting change and believing that our informed actions are doing good, we live out a master narrative of Western science.

The right use of translations: This is the skill of translating standardized knowledge into representation of everyday life—and vice versa, analyzing our everyday life situation in terms of standardized knowledge. Trout were the theoretical constructs of a successful riffle and also physical beings we sought to discover resting in the pool. Logs and bankside trees became “large woody debris” and undercut bank became “habitat.” The talk around the riffle building was rich with these translations.

The ability to contrast the understanding of a technology with the understanding of its scientific principles: This refers to the difference between understanding how to use a fax machine, what it is useful for as opposed to e-mail or telephoning (technological understanding) and the scientific principles behind its operation. There was not much of this discourse at the riffle site, as the technology involved was simple and non-problematic.

Right use of knowledge and decisions. “how do we teach young people to relate scientific and technological knowledge to ethical and political decisions?” (Fourez, 1997). At the riffle site our discussions continuously turned around this topic: what the creek’s problems were, who was responsible for them, what was it about the political economic climate that encouraged the problems. After a day at the riffle, students would be well versed in many versions of how science and decisions have been related over the years.

The experience of building the riffle was strong in terms of the following categories: specialists, simple models, metaphors, translations, knowledge and decisions. It was moderate in terms of black boxes, standardized knowledge and not a great learning area for interdisciplinary models or the distinction between science and technology. This reflects the relatively simple technological nature of the task, which did not require much use of instrumentation or drawing specialists from a wide variety of disciplines.

Overall then, with 6 of Fourez's 10 categories strongly represented in the riffle-building experience, we are justified in our claim that this is a good way to teach students practices that would result in scientific literacy.

Practice

Throughout the history of the riffle construction, the practice of this science-based activity is significantly different from that performed in classrooms. The science was purposeful: it had a strong goal that it supported which had nothing to do with the advancement of science per se or "getting it right" to please an authority. The goal of enhanced watershed and stream health determined the type of the science carried out in the project. And in return the results of the science shaped the actions and discourse of the activists.

The science enacted in this case study is aptly described by Bourdieu's "economy of logic" (Bourdieu, 1997)—no grand narratives were constructed and painstakingly checked and double-checked. Science was used as a tool to help people determine what was appropriate action to take. People's activity while building the riffle was directed toward working in community to build a structure that functions properly. There were no authorities withholding marks for not doing it fast enough or in exactly the right fashion or not understanding the underlying concepts—as during the Initiation, Response, Evaluation sequences of teacher-student interaction (Poole, 1994) that reify notions of science as a body of fact. Peoples' activities were guided by what needed to be done next in the construction sequence. The fading of the daylight and threat of oncoming winter rains gave the project its urgency rather than by an impending bell signifying an authority's decision about what to do next. Thus, the experience of time while working on the riffle was closer to that of the practice of both professional and everyday science based activities. In these activities, urgency is embedded in daily rhythms (meals, bed time) and activities determined by the next step necessary for the successful completion of an experiment, design project, or course of treatment. The activities embodied the fuzzy and economical logic described by Bourdieu (1990) and were rich in improvisation, adaptation and embodied knowledge. Based on this view of the nature of

practice. participants gained a legitimate experience of scientific practice, and of practice in general.

Connections

One of the most outstanding aspects of the science enacted by the activists was its connectedness to its community. Geographically, technically, and discursively the science was profoundly influenced by its relationships. This science was not confined within four walls. It traveled to multiple locations: municipal council, landowners' living rooms, Henderson Creek, committee meetings, etc. Through its travels it changed its meaning and its form, from an inconvenience discussed between individuals in the horse community, to the formal presentation of data in a technical report to the municipality to a group of people building a riffle. Each site and corresponding community contributed to and shaped the project.

The science as enacted was determined entirely by the community. Its land-use practices created the "problems" to be solved, the funding available determined the extent of work that could be done and the people who participated in and supported the project allowed it to happen. However, science provided a legitimate description of the problems, and justified the group's actions. Inasmuch as scientific description is likely to convince people that action is needed, science defines the problems and guides the community's action.

As was exhaustively demonstrated earlier, the riffle construction was tightly woven into the community. Many people came by to help, visit or advise. Through these stories, we become more deeply rooted in our community, absorbing its language and rhythm, priorities, and history. As the participants come to know a place—its people, its history and politics—a sense of belonging develops which is a crucial ingredient for being able to inhabit a place as a Heideggerian dwelling. Sensitivity to biogeographical surroundings develops a feel for shared cultural history and the forces that shape our habits and assumptions. We learn about that part of us which is the land - its needs for proper treatment, its native tendencies and become intimate with it by sticking our hands in it and shaping it. Therefore, the ultimate learning that goes with this type of activity is one of a relation of Self to Other, a becoming in the world.

By participating in the project, even for a day while building a riffle, one becomes an increasingly empowered social actor. Much of the talk during the day at the riffle deconstructed taken-for-granted structures (ditches, storm sewers, etc.), and opened them to critiques. Through participating in this discourse, we begin to analyze and critically think about our place rather than passively accept whatever some authority decrees.

Conclusion

The kind of science described in this chapter is quite different from that being currently taught in schools. I make no claim that “this is the only way,” nor that all schools teach the kind of science I criticize, but rather am providing a different framework with which to understand scientific literacy and show some opportunities available to help students develop meaningful relationships with scientific practice. I want to afford students the opportunity to contribute knowledge to the community at large through their engagement. And I want to get more students to participate not in the science of scientists, but in science as it permeates everyday activities in our communities. I envision a school science that includes purposeful projects, multiple sites, a wide range of literacy skills, and a focus on practice. One that goes beyond the “cold” science of facts stripped of politics and passion to a science densely woven into the interests that shape it and in return are shaped by it. A science education that is not a preparation for a future life, but is an active legitimate participation in a community.

Chapter 7: How Ditch and Drain Become a Healthy Creek: Representations, Translations and Agency during the Re/Design of a Watershed

This piece was written in the winter of 1999 and then extensively re-written a year later in response to reviewers' comments. A version of it was accepted in spring 2001 to the journal "Social Studies of Science," which is the foremost forum for scholarly articles in this field. In this journal great importance is placed on theoretical development of the data. Its intended audience is other scholars in Science and Technology Studies, particularly those interested in new studies that advance the conceptual vocabulary of the field. The editors chided me to relate these findings to others' work, and to demonstrate how this work fit in with and advanced the thinking of the field. So more than any other chapters in this thesis, the events at the community level are treated theoretically.

A wide range of data sources supply the material that is analyzed in this text: reports, letters, scientific forms, diagrams and web-sites written by the activists, my field notes, and videotapes of activists in the field. Both Michael and I noticed the diverse proliferation of representations I was bringing back from the field. This article is my attempt to make sense of them.

This chapter is the only one in the dissertation that contains substantial, substantive contributions from Michael. In the section "Inscribing Gordon Creek," he provided the descriptions of the forms, and the activities involved in filling them out. I provided the analysis about the forms' role in the activists' activity. He also provided the analysis in the "Two for One" section, where the different uses to which the same photograph was put was made. Finally, the analysis of the different representations of the riffle ("Inscribing the Riffle") and the gestural analysis of Colin the consultant ("The Ephemeral Riffle-in-Setting") were Michael's. Although it is normal that an advisor influences and shapes a dissertation, I feel that these contributions are such that they should be marked. Even though I developed much of the theoretical frame, there are contributions Michael made for which I do not want to take credit. Therefore, Michael's contributions are bracketed by [WMR – start] at the beginning and [WMR – end] at the

end of each one. The overall theoretical framework, discourse about democracy, every other analysis and the considerable work involved in unifying such a diverse paper was mine. I also provided the inscriptions and videotape that his analyses were based on.

The purpose of the piece is to document the representational work that the activists do in first defining and then changing a creek. How is change, both to the landscape and the social world, achieved? Different types of representations created by the activists are presented. The narrative follows their travels, notes the relations that they affect, and shows what the effects of these changed relations are.

This is a paper that focuses almost exclusively on the relations between things. Things never stand alone, they come into being through series of transformed relations, they re-transform them and they become transformed by them. This is a type of ontology embraced by many STS scholars as a way to avoid essentialist descriptions of phenomena (Callon & Law, 1996; Latour, 1999a; Mol & Mesman, 1996; Mol & Law, 1996). This method of description is used in this chapter to make sense of how things work at a municipal level, where disciplinary boundaries blur considerably, and densely articulated relationships are the norm.

Thematic Issues

The theme of scientific representation and science activity is deeply explored in this chapter. The work that representations do, how they are created, how they embody politics and where they go is not broached to this extent in any other chapter. Topics include: the politics of ‘thinning’ nature to represent it, the theory implicit in forms, the pedagogy associated with labelling photographs, the way that signs can be used to augment personal memory, and the importance of creating not only material changes in a landscape, but accompanying social changes if these material ones are to remain durable.

The secondary theme developed is one of democracy. Because representations and the act of representing are tied so deeply to political activities, the political effects of this activity were constantly apparent. I argued that the agency involved in making and circulating representations is one that supports democracy. As more people can speak, as more people come to be familiar with a landscape, democracy is strengthened. At the same time, however, I acknowledged that within the format of the forms and the

interrogation of the stream are hegemonic assumptions that, for example, exclude First Nations' ways of knowing. The scenario is never straightforward.

Scientific literacy is not explicitly addressed. Yet by legitimizing the activists' activities, and by naming the volunteers' work as science, the position that they are engaging in scientifically literate activity is supported. Similarly, relationships are not explicitly mentioned. But by presenting reality as something that arises from inter-relations of things and people, the importance of relationships becomes obvious.

This paper is the most in-depth and explicit treatment of the activities that representations participate in and the most direct comment on the democratic aspect of the political practice of science-based activism.

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How Ditch and Drain Become a Healthy Creek: Re-presentations, Translations and Agency during the Re/Design of a Watershed

Introduction

This paper is about a creek. And about people who claim to speak for it and, indeed, for all the water in a watershed.¹ In another sense, this paper is about how a creek inhabits different worlds, and how people who co-exist with it in those worlds struggle to align the creek with their preferred practices. A creek that becomes “fish habitat” is gone from the farmer’s working world. As fish habitat, it falls under the guidelines of habitat protection issued by the Department of Fisheries; and the farmer can no longer pump out water for irrigation, or plant crops within 15 meters of it. If a “drainage ditch” becomes a “fish-carrying creek,” then the municipal engineers must alter their practices and stop cutting vegetation from its banks and the creek will not drain water from the land as well. The engineers must rearrange the entities of their world and create a new set of relations to keep the homes in the municipality dry.

However, these changes return the creek to the fish. Bankside² vegetation and higher water levels mean that a creek is now a place where fish can live all year long, hide from predators and find enough food to reproduce. The fish have been given a world to inhabit, a habitat. To the environmental activists who work to recreate the creek in the community, healthy fish mean healthy people, people who live sustainably within the limits of the landscape’s water cycle. In this study, I write (about) the efforts of these community activists to construct the creek in many different spaces within the municipality in service of the goal of sustainability.³

¹ ‘Watershed’ denotes that land which drains into a common watercourse. The boundaries of watersheds are high points of land, the opposite sides of which drain water down into different creek systems.

² Literally, vegetation that is growing on a stream’s banks.

³ Henderson Creek Project’s mission statement is: “To protect and enhance the Henderson Creek stream system in order to maintain sufficient water quality and quantity so to achieve the best possible balance between ecological and agricultural needs of the watershed, and to maintain these watershed functions for future generations”.

Bringing about community-based change is not a simple task. Meaghan, the coordinator of the activist group in this study says: “It’s like trying to pull a single brick out of a wall. You think you’re just trying to change one thing, like a creek, but you soon realize that the creek is connected to all sorts of other things—bylaws, economics, history.” I piece together the “brick-pulling” and “brick-laying” work of the activists as they use a variety of different inscriptions, some scientific, some a hybrid of science with other registers, to re-create spaces,⁴ both local to and removed from the physical creek, in such a way as to facilitate the ecological creek’s inclusion within them. The health of the creek, for the first time, becomes part of the discussions at the municipal hall, is taught in a grade-7 classroom, or is written about in the local newspaper.

A material semiotic framework is used in this narrative and I share the contention that ‘this version of semiotics is not about meaning: it makes one try to find out instead what elements, of whichever character, associated in whichever way, make each other be’ (Mol & Mesman, 1996, p. 429). Thus, the creek as re-presented by inscriptions is not “interpreted” by some Other, but instead becomes part of a new arrangement, a new collective that is different from what it was before the re-presentation had joined it.⁵ There is no opposition between “inscription” and “interpreter”: they co-define each other as they co-participate in an event.⁶ In the event-space of the municipal hall, the creek is created by and through the relations of semiotic elements contained within a report—including diagrams, photos, councilors, paper, citizens and scientific register—with the people in the hall. Hence I write how the activists re-present or create the creek in different locations, the municipal chambers, schools, and bureaucrats’ files.⁷

⁴ We mean spaces in Law and Callon’s (1995, p. 494) sense of “discretionary space” as a space created by a confluence of machines, people, re-presentations and so forth, “a space where options may be exercised... a mode of ordering which defines and distributes the character of persons and papers”.

⁵ We use the term collective in the sense it is used by Latour (1999b, p.304): “the associations of humans and non-humans”, and Callon’s ‘collectif’ “an emergent effect created by the interaction of the heterogeneous parts that make it up” (Callon & Law, 1995, p. 485).

⁶ Our de-centered notion of ‘event’ is very similar to that articulated by Gomart and Hennion describe “A rock concert... [which] does not bring together already existing objects, subjects and social groupings—rather, this is a conjunctural event in which the relevant objects, subjects and social groupings are co-produced” (Gomart and Hennion, 1999, p. 228). Similarly, Latour (1999b, p.281) writes of a confluence of humans and non-humans which participate in an event where both emerge transformed.

⁷ We relate this idea to Law and Callon’s notion of translations, which ‘make the things, texts and people’ (Callon & Law, 1995, p. 501).

Since I speak of being as a result of semiotic arrangements, this framework allows the articulation of change as a change in the social-material arrangements of a locality, which can be documented.

The activists' work of convincing, assuaging and conscripting many different institutions and individuals is portrayed as the work of rearranging how these localized entities normally interact.⁸ Recent work in STS highlights the discontinuous nature of communities, and their effects on the ontology of a social-material entity (Law & Mol, 1995; Moreira, 2000). For example, a water pump in Zimbabwe is not a fixed entity but, much like a fluid, is a different thing with different properties depending on where we as narrators, locate the boundaries to demarcate it (de Laet & Mol, 2000). Such a water pump must be connected to an appropriate community, health, and material beings to maintain itself as a pump working in a village. I portray much of the activists' work as attempts to re-create and then re-align the different spaces within their community in such a way as to gain the resources and permission to do stream restoration work and shift social relations in the community to include an ecologically defined creek. This aspect of the theory allows us to clearly articulate what the activists do.

By restoring their creek, the activists re-create it as one that is "ecologically correct." As the activists add material structures, such as "large woody debris"⁹ and boulders, they enact strategy that "both organizes and produces material distinction" (Law & Mol, 1995, p. 282). As a result of this strategy, the creek becomes a more livable environment for fish, making it more difficult to use it as a drain and ditch. This "healthy creek" then becomes re-inscribed and travels back to places both within and beyond the community in the form of inscriptions that the activists construct. There it does even more work, by further rearranging relations. I describe this cycle of translation (Callon, 1986; Latour, 1990), circulation (Henderson, 1995; Latour 1990), and rearrangement of relations in the activists' work.

⁸ Of course, in the process, the activists create themselves in the community as well, a point that is not lost to them.

⁹"Large Woody Debris" is a creek restoration term to indicate various logs, branches etc. that contribute to fish habitat by providing shelter for the fish, reducing the flow of the current, provide environment for insects that the fish eat and so on.

Science is politics by other means (Latour, 1988, p. 229). So goes Latour's famous dictum. This study about the generation, variety and uses of scientific representations by a grass-roots environmental activist group is therefore one about grass-roots politics. Community participation. A more democratic process.¹⁰ Throughout this narrative, I argue that the activists' work enacts three facets of a more democratic science. First, the scientific "franchise" is extended to a greater number of people. Science becomes democratized as more people are included in its practices.¹¹ Second, scientific re-presentations are skillfully used by people outside of the legitimate, institutionalized scientific world, to do political work. Thus science participates to a greater extent in community politics. Third, because the activists are marginally situated within the community, and cannot impose their imperatives on others but require, for example, the support of horse riders of the municipality, a hybrid practice of science emerges, one whose arrangements include the limitations and concerns of the local community. STS has often argued for the ideal of a greater inclusiveness, and this inclusiveness shapes its democratic political goal.¹² I draw on this tradition and therefore use the term "democratic science" to describe practices that I believe are more inclusive.

At the same time as I argue for its presence and value, I also problematize the ideal of democratic science. The descriptions of nature that the activists use, for example, do not include economic or engineering concerns. By creating a scientifically correct stream, they are enacting bureaucratic imperatives imposed by the provincial and federal governments, and thus their hegemony. In this paper, I hope to portray community based science as it appears to me: a process by which more actors—the activists, the scientifically described creek, the trout—are included in the network of relations that makes the stream, but also a struggle of voices working to bring about change they believe is best for the community.

¹⁰ Many authors in STS confront and challenge science's relation with authority in support of a more inclusive, democratic process. For some examples, see Alan Irwin and Brian Wynne (1996), Bruno Latour (1997), or Susan Leigh Star (1991).

¹¹ This goal of the broad inclusion of the demos in articulating the world is explicitly discussed in Latour's *Socrates and Callicles*, (Latour, 1997).

¹² For a detailed thoughtful discussion of the notion of inclusiveness within ANT, see Nick Lee and Steve Brown (1994), and Nick Lee and Paul Stenner (1999), also Law and Callon (1995).

Re-Presentation at Work

Michel Callon and John Law suggested that we think about a community not as a single place, but as a set of places, or rather, a set of overlapping places (Callon & Law, 1995, p. 504). In this paper, I treat a “community” as a patchwork¹³ of partially connected places. Thought of as a patchwork, a community is neither a coherent, completely connected entity nor a conglomerate of isolated and fragmented worlds. Rather, a community becomes a place defined by partial connections that exist and are established between sites, situations, and stories (Law & Mol, 1995, p. 290).¹⁴ For the most part, I use geographic and topological distinctions to delineate the places, and relations between people and mobile inscriptions as the connections, but also define a second kind of place as a group of people who recognize themselves as a group engaged in a coherent activity, such as the Henderson Creek Project. The activists work in this patchwork community that includes hay farmers on their tractors in their fields, horse riders and horses and expensive parcels of property, park administrators, parks and so on. They travel the landscape, interrogating it with their instruments and procedures, and re-present it (and the Project) in different places within this patchwork, creating new (series of) relations and changing other, already existing ones. In this section, I describe some of the representational practices that they enact to understand, re-present and use the creek to bring about the new set of relations they imagine would be healthy ones.

The patchwork is traversed and connected by the flow of entities (often inscriptions) that participate in and transform existing relations. From the beginning of this research, I noticed the considerable effort mustered by the activists to produce and circulate scientific and non-scientific inscriptions that re-presented numerous different entities related to environmental issues in the watershed (e.g., creek, a fence, environmental health, water quality). The power of inscriptions arose here, as elsewhere, in part from their nature as immutable mobiles (Latour, 1987), which allowed them to travel virtually unscathed to any place in the world. As such, they can be circulated to

¹³ Law and Mol introduce ‘patchwork’ as a theory metaphor that emphasises entities as local, inherently unstable, and without discernible direction (Law & Mol, 1995, p. 275).

¹⁴ Also relevant here is the description of the ‘convergent diversity’ of scientific practices described by Goodwin (1995) on an oceanographic survey ship.

wherever an agent wants them to be. Producing and circulating immutable mobiles is therefore a central aspect of knowledge-producing communities. As I participate in and observe the practices of the Henderson Creek Project members, I notice this aspect of science at work. The activists do not just draw on the inscriptions and discourse created by scientists as has been documented in the case of U.S. AIDS activists.¹⁵ Rather, in a bricoleur-fashion our activists generate their own scientific representations that they subsequently insert, layer, multiply, transform, and circulate in the service of rhetorical purposes (e.g., changing local by-laws, garnering funding). Our activists constantly re-represent their findings and positions to enter them into brochures, legal discourse, proposals, or local dialect. But in these insertions, I discover that what had appeared to be immutable turn out to be highly changeable entities. Thus, a picture is not just a picture that says the same thing wherever it travels. In fact, pictures and other inscriptions say different things depending on the other entities that they are in relation with. And even these other related and connected entities do not maintain their identity, but change once another entity is inserted. That is, each specific form of insertion constitutes a new and different mix. Sometimes a mix asks for the incorporation of everyday metaphors, sometimes a mix involves the layering or juxtaposing of different representations in unique ways. I use the term mutable mobile to highlight the (interpretative) flexibility and adaptability of each inscription in the hands of activists.

Communities use immutable mobiles to organize work within, and across their boundaries into other communities. In this sense, immutable mobiles are “boundary objects.”¹⁶ Those in power often create these boundary objects, including standardized forms, protocols and libraries, to co-ordinate the activity of the group they manage. Mutable mobiles, although they have fluid character, also perform important boundary work. But, unlike Leigh Star’s managers of computer software companies or directors of

¹⁵ Steven Epstein (1995) provided detailed description of the way AIDS activists appropriated scientific topical and methodological discourse, which allowed them to participate in the discourse and change it in the process.

¹⁶ Although, as noted earlier, they are not treated as “the same” object being interpreted by different communities of practice, but rather participants that are circulated between different locations. Their beings arise out of the subsequent events in which they participate. For the traditional elaboration of boundary objects, see S. Leigh Star and James R. Griesemer (1989), S. Leigh Star (1989), and Kathryn Henderson (1991).

museums, our activists are not the ones crafting the bylaws determining farm drainage or engineering the storm sewer system. In order to bring about changes, they must adapt their re-presentations to insert ecological discourse into boundary objects that have been created by others. Thus the diversity observed among the activists' mutable mobiles reflects their position as a marginalized part of the community, as they must adapt to their discourse to fit into others' constructions.

But the activists are not interested in circulating inscriptions for their own sake. They are interested in changing the water-related practices and the physical landscape of the municipality. To do this, the inscriptions must do the work of helping to change the social and material relations that currently exist. New bylaws need to be drafted, new alliances forged. People must begin talking about 'channelized stream' and not 'a ditch'. In the following, I choose some particular inscriptions to highlight the changes in the social-material relations that they appear to create and facilitate.

From 'Thick' Objects to 'Thin' Descriptions

Activists commonly engage with science rhetorically, attempting to influence how science, done by scientists in legitimate research institutions, is performed.¹⁷ Others are able to hire Ph.D. scientists to do research or produce reports.¹⁸ The Henderson Creek Project does not have the money nor the access to lab space to do such research. Rather, members, or youth hired on short-term assignments engage in activities that turn (objects of) the watershed into inscriptions. They survey the creek, monitor the water table, make GIS representations of the watershed and perform qualitative and quantitative analyses of water quality and stream health (consistent with the government-approved "Streamkeepers"¹⁹ program). I focus on the activists' work to create and then modify an in-stream structure, a "riffle" in Community Park, as our primary example of this activity.

¹⁷ Steven Epstein (1995), for example, described the appropriation and use of scientific discourse and representations by AIDS activists. As a result of this appropriation and insertion of inscriptions into their own discourse, AIDS activists were able to change scientific practice such as the establishment of protocols for scientific testing of drugs.

¹⁸ The environmental activist groups studied by Helford (1999) and Eisenstein (1999) are examples of this type of activist organization.

¹⁹ 'Streamkeepers' is a program sponsored by the provincial government dedicated to training and supporting citizen-based stream assessment and restoration. The program provides a thick binder of

In the first half of our narrative, I describe some activities involved as the activists surveyed the creek through Community Park, incorporated the survey information with multiple other re-presentations of the creek, and created a report which was also a request for municipal support to do work in the stream as it flowed through the Park. The creek was translated into and re-presented in the form of numbers and text on the assessment forms, and these forms became part of a binder full of creek re-presentations stored in Meaghan's office. When Meaghan wrote the proposal, the inscriptions not only re-presented but also created a particular Henderson Creek through the juxtaposition of text and images.

Throughout this narrative I use the term 'thinning' to refer to the material transformation that a natural entity, such as a creek, undergoes as it becomes re-presented as a scientific inscription. But thinning does not just mean made smaller, or simplified.²⁰ As Lynch shows, the properties of the entity under study are transformed eidetically, so that they embody the relevant theoretical context (Lynch, 1990). When relations among those doing the thinning are unstable or contested, the thinning process can be a politically contested one, as different agents struggle over what gets included in the thinned re-presentations and what the outcomes of the new re-presentations may turn out to be.²¹ In this case, the forms that structure the activists' thinning work are supplied by the Ministry of the Environment, and thus embed its political mandates. Thinning can also refer to the erasure of contextual detail that inscriptions undergo as they participate in successive rounds of translation from more local to more general re-presentations (Geertz, 1973; Ryle, 1971, pp. 465–479; 480–495).

I begin the analysis with a detailed analysis of some of the re-presentational practices involved in this work. In particular, the processes of entering stream data onto a

theoretical information and weekend-long courses in which participants learn how to assess a stream for physical, chemical and biological properties. The Streamkeepers program considers a stream's fitness to support salmonids (salmon and trout species) as its normative standard.

²⁰ Although, as Latour (1990) points out, this material transformation into an artifact that can be easily seen in its entirety, manipulated and transported facilitates much of scientific practice.

²¹ Ken Alder (1998) used the word 'thinning' to describe both the changes in a material representational practice of engineering illustrations, and also gave a rich description of the historical struggles surrounding the implementation of this practice. A similar account of the organizational politics commensurate with thinning is given by Diane Vaughan (1999) in her article on the successive reductions of uncertainty in the assessments of the safety of the space shuttle Challenger's solid booster rockets.

Streamkeepers water quality form is outlined (this analysis contributed by Michael Roth). The use of this form has many advantages for the activists. By making the creek 'thinner' as the surveyors work through the calculations on the form (see Figure 1d), the representation becomes 'weightier' in terms of its impact. The thin form becomes 'weighty' due to its relations.²² It has been constructed as part of a provincial initiative to increase citizen stewardship of salmon bearing streams. So it is a representative of the provincial government. It can speak before council with authority, or be understood instantly by a provincial bureaucrat allocating funds. Thus it can precipitate an entirely different set of effects than the physical creek can because it travels to and fits within the relations of spaces where decisions are made that affect the allocation of material, financial and legislative resources. It can participate in strategies designed to alter the physical creek, and the social relations that shape its interactions with humans, their tools and their waste. In the political arena, this thin form is 'weightier' than the mute, rushing creek.

I show that the form does the work of a center of translation, providing built-in methods for condensing and transforming data. The form supplies the surveyors with built-in formulae and graphical relations that allow them to transform the input of non-humans like pH meters into numerical factors whose meaning reflects the discourse of stream ecologists (demonstrated by Michael Roth). Thus the form ensures that an ecologized creek will be re-presented by those who are examining it, it is an embodiment of stream ecology (Lynch, 1990).

The other advantage of the form is that it democratizes the analysis of the creek. Because ecological theory is embedded within the graphs and calculations on the form, anyone with a minimal training can collect data and therefore participate in science. Work done by high school students can be just as important to the cause as work done by a Ph.D. candidate. This allows the activists to do scientific research through the efforts of a heterogeneous group of people, many of whom are not certified scientists. In this way the forms are very similar to those forms and protocols described by Star and Griesemer (1989).

²² Latour (1999b, pp. 70-71) also talks about this shifting of properties as the gains of standardization, compatibility, universality etc. made through 'reduction' of a phenomenon by scientific practice.

Inscribing Gordon Creek

Before it becomes re-presented to council in the proposal to do in-stream work, Gordon Creek²³ sits on a shelf in Meaghan's office. It has been sketched, photographed, surveyed, measured, assessed, and collected into a bundle of papers in a large binder. The binder includes representations such as photographs, maps with naturalistic details (Figure 1b), geographic maps, tables, forms, and line graphs. In the following section, I trace a typical sequence of the translations involved in the production of these representations.

There are a variety of iconic re-presentations in the section of the binder devoted to Gordon Creek as it flows through Community Park. [WMR – start] Photographs are the most 'naturalistic' of these, but they cannot do the kind of work other re-presentations do. They are full of 'gratuitous' detail on the one hand, and lack scientific information that provides necessary rhetorical strength on the other. The activists use them to record what they consider to be the significant features of the reach.²⁴ They also sketch maps augmented with naturalistic drawings of the entire stretch (140 meters) that include the positions of trees, rocks, and mossy areas (Figure 1b). These are used to get 'a feel' for what the habitat is like in that particular segment of the creek. Other maps include elevation profiles (Figure 1c) which describe the elevation along the length of the creek, and a series of cross sectional profiles taken at a number of points along the reach. These re-presentations were created using computer software packages which translated surveying data (numbers) inscribed into the little yellow surveying notebooks (this raw data is not included in the binder) into graphical form. The two profiles are later combined to create three-dimensional re-presentations of the creek, modeling its topography as it courses across the landscape.

Included in each reach collection are habitat (Figure 1a) and water quality (Figure 1d) assessments. These are forms that involve representations and translations to arrive at some judgement about habitat rating (e.g. "marginal") or water quality (e.g.

²³ Gordon Creek is the main tributary of Henderson Creek that flows through Community Park where the activists built a series of riffles and reinforced the banks.

²⁴ One reach of the creek is defined as the length of creek between a geographically significant starting point and end point.

“acceptable”). Each form acts as both a record for numbers read off instruments or generated by human-as-instrument and an authority which tells the surveyor how to translate these quantitative values into qualitative judgements. In determining the water quality score, the surveyor translates numerical values read off instruments, such as a dissolved-oxygen meter, by means of a ‘Q-value’ curve, into numerical indications of water quality. And on the habitat assessment form, numerical judgements of non-numerical assessments (e.g. ‘seasonal off-channel habitat’), allow the ‘summation’ of a variety of habitat features into a number which then corresponds to a qualitative assessment.

The establishment of water quality involves the water quality data form. The individual using these forms records, besides information on the locale, weather, date and time of data collection, a number of “scientific data.” These data include air and water temperature (to 1 decimal), dissolved oxygen concentration and saturation, pH, and turbidity. Each value entered in the form was itself read off an instrument—each instrument being a black-boxed set of processes that translated the creek into a number that has the power to speak for the creek in a different locale (Latour, 1990).

The numbers from the water quality form are then transcribed onto the “water quality survey interpretation & results” form into the left most of three columns. The results of the chemical tests are converted into a “Q value” by reading from a line graph that appears in a Cartesian grid, spanned by the range of chemical data on the abscissa and Q values on the ordinate. The Q-value determination is accomplished through a process of reading (which can be aided by a finger or pencil) in which the chemical reading is mapped onto its corresponding Q value via the curve: move vertically to the curve, then horizontally to intersect with abscissa.

To arrive at the next stage in the sequence of translations, each Q value is multiplied by the ‘weighting factor’ (pre-inscribed on form) in the column to the right of it, and the result entered in the ‘index value’ column to its right. These index values are then added to produce yet another number that comes to summarize a complex set of measures, processes, and ecology. But this is not the end of the story. Yet another translation has to be accomplished. A water quality chart, which translates ranges of numbers into a verbal assessment (good, acceptable, marginal, and poor), transforms

these numbers into an index of water quality. By finding the range within which the summed indices fall, the user determines the water quality. This result is subsequently transcribed into yet another form, the “Henderson Creek Watershed Survey Data Summary Info” sheet where the results of other, similar extensive translation processes are entered (e.g., habitat rating, flow discharge, length of reach, slope).[WMR – end]

This is the process whereupon “raw” data is “worked up” or translated through four separate steps. The Q-value graph, the weighting factors and the texts that correspond to numerical ranges all contain much theoretical work in the science of stream ecology. They are the relations of pH to fitness for trout, for example, that have been determined through much work over many years in the field. These numbers are ecological theory ‘black-boxed’ and made mobile through their inscription on a form. No scientist is needed to interpret the non-humans’ numbers, as their contributions are already present and at hand for the surveyors. These forms, which not only tell the relatively novice surveyors which measures to take, but then interpret the meaning of these measures for them, contribute in a crucial way to allow uninitiated, untrained people to participate in scientific practice. They translate measurements and produce numbers which are meaningful in the practice of stream ecology without having to know the basis behind the relationships graphically represented on the Q-curve, or why a total score of ‘37’ means “acceptable” water quality.²⁵ Thus science is democratized. The experts have multiplied and become mobile, and support ordinary citizens’ participation in ecological practice, generating inscriptions and adjectives that are not different from those of professional scientists.

[WMR – start] The habitat assessment form also looks innocuous, as it requires what appears like a simple classification of the habitat according to nine different characteristics (Figure 1a). But in this case, unlike the water quality form, each assessment requires translation of a visual impression into one of the representations pre-inscribed on the form. For example, assessors are asked to look at the streambed and estimate if there is more or less than 10% boulder and cobble. This assessment is then

²⁵We do not intend to suggest that such assessments are simple processes. As Hutchins (1995a) and Lemke (1999) show, there are multiple cognitive, perceptive, motor, and social factors in accomplishing the following of an instruction.

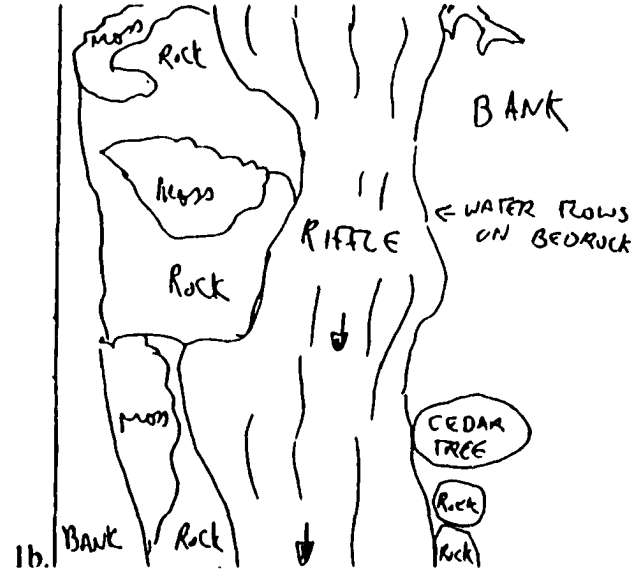
attributed a numerical value and is inscribed in the right-most column. Once all the cells corresponding to the nine characteristics have been completed, the individual scores are summed into a total score. The total is then mapped onto a qualitative expression by searching the range into which the total score falls and matching the verbal expression (good, acceptable, marginal, and poor) corresponding to the range. This verbal expression is then transcribed into another form.

The forms can be seen as doing work. They discipline the observers by providing slots that want to be filled, giving a structure for accomplishing the next step in the translation (Latour, 1999b, pp. 46-47; Roth & Bowen, 1999). In the forms, we have (little) centers where compilation and translation work can be done on the spot, in the here and now of the situation. Complex operations provide seemingly insignificant transitions over what should be treated as ontological gaps (Latour, 1999, pp. 68-72). In practice, of course, work gets done as if there was no gap (which, nevertheless, shows through in each hesitation whether some entity should be classified in this or that category). In both instances, the form provides not only for a means of 'recording the data', but also for compiling and translating inscriptions into further inscriptions and into an end-point, the assessment. [WMR – end]

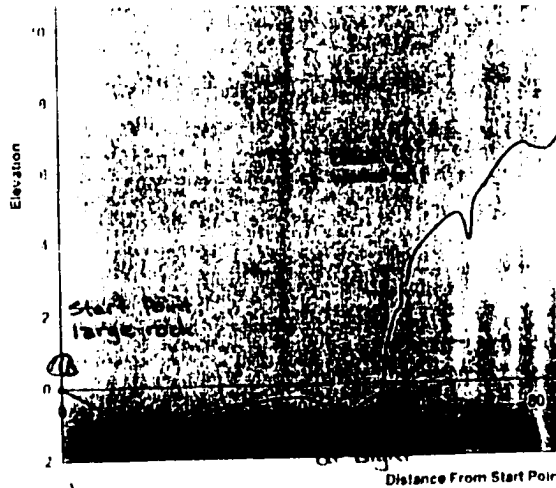
They also accomplish important theoretical work. Whereas it is impossible to construct a compound score from, for example, "off channel habitat is seasonal, good protection" and "there are 30% boulder and cobble," the numerical scores attributed to the qualitative assessments by the standards of stream science allow a mathematical operation that translates nine scores into one, "habitat quality." The habitat quality of a stream, for fish, is determined through a translation of numerous qualitative assessments of the environment into a numerical value. Thus the stream becomes mathematized, or thinned, through the role of the form in the activity of stream surveying. The next and final translation performed is one that moves from a numerical value back to a qualitative judgement – "good" habitat quality. Stream ecology, bureaucratic mandates and the form become black-boxed into a qualitative judgement. In this thinning process, scientific discourse disappears but is integrated into a single word that informs the community about the quality of the creek.

Characteristic	Good	Acceptabl e	Marginal	Poor	Score
1 streambed material % boulder and cobble	15-20 50%	10-15 30-50%	5-10 10-30%	0-5 -10%	5
4 Off channel habitat	11-14 year round good protection	7-11 seasonal, good protection	3-7 seasonal, minimal protection	0-3 little or non, no protection	2
TOTAL SCORE	102-135	66-102	30-66	0-30	44
Habitat Rating	<i>marginal</i>				
Comments	<p><i>Creek bed is almost all bedrock riffle, very little pool.</i></p> <p><i>Riparian species: maple, cedar, Douglas fir, alder, sword fern, lady fern</i></p>				

1a.



1b.



1c.

Figure 1.:
 a. This is a table of the translated habitat quality values.
 b. this figure is one of the naturalistic maps drawn by the surveyors, noting features of the habitat they consider significant.
 c. This is an elevation profile made by a computer program which interprets the survey data the activists have inscribed.
 d. (next page) This is a scan of the small 'centre of calculation' where the surveyor is led to translate various chemical parameters and produce a water quality rating

Water Quality Survey Interpretation & Results

Chemical Test	Result	Q Value	Weighting Factor	Index Value
Temperature Change	3.1 °C	83	x 0.10 =	8.3
Oxygen Saturation	76.7 %	80	x 0.17 =	13.6
pH	7.38	83	x 0.11 =	9.13
Turbidity (FTU)	8	80	x 0.08 =	6.4

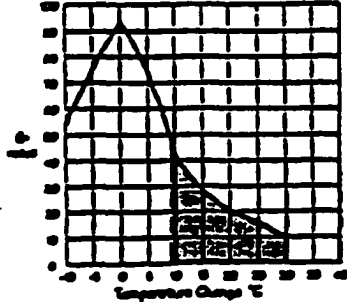
Total = 37.43

Water Quality Chart	
Good	40-45
Acceptable 37.43	30-40 ✓
Marginal	20-30
Poor	< 20

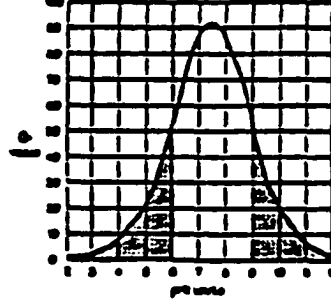
fig. 1d.

■ = Q-value less than 50

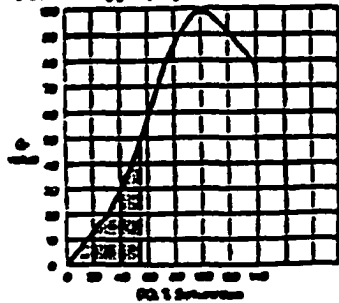
Temperature Test Results



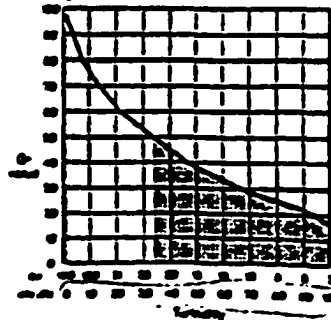
pH Test Results



Dissolved Oxygen (DO) Test Results



Turbidity Test Results



adapted from Mitchell and Stapp, 1991

The re-presentation of the creek in terms of the standards of stream ecology has at least three advantages for the activists. First, as formal tools they both organize the observational work and contain a model of the world that they describe.²⁶ Therefore, almost anybody can participate in stream surveying with minimal training. The theory of stream science is already embedded within the forms so that the surveyors themselves do not need to know it. Yet the forms constitute protocols that allow the individuals to collect the standardized data subsequent users of the data need to compare them across context. Second, because the forms contain a model of the creek consistent with stream ecology, the gathered data is already intelligible to the experts with whom the activists consult. The experts can receive meaningful direction without having to spend hours in the creek themselves. The scientists take the form as a guarantee that standardization across non-standard domains (lay people versus scientists) has been achieved whereas the activists see the form as a way of enhancing their chances in receiving funding. And third, the activists can speak about the health of the creek in a way that carries weight in the public arena. When they make claims about the creek's health, they can return to their forms to validate their claims. The forms' titles are "water quality" and "habitat assessment," which in fact, they are neither. The title of the form thins it one step further, this time deleting the context in which the quality is determined, again making the form weightier, from representing fitness for salmonid fish to one representing "water quality." Now instead of advocates for fish, the activists become advocates for health, which is a significant difference, and allows them access to a wider variety of rhetorical claims in arguing their case in public.²⁷

As actors in a social-material space the Streamkeepers forms provide conditions for others to initiate work that otherwise could not have been imagined. They are an important component in the agency of the activists and others in the community who use them. Now, for the first time, high school classes can do course work by surveying the creek. Volunteers get together to spend a weekend mapping a few reaches and sending in

²⁶ In "The Externalized Retina", Michael Lynch (1990) makes the point that the mathematical nature of the world is the result of doing the articulation work between an inherently mathematical inscription and an a priori unstructured dynamic continuum.

²⁷ For a similar shift see the changing identities of the Zimbabwe Bush Pump, a mechanical entity that is a source of water to one as a source of health (de Laet and Mol, 2000).

their data to the provincial stream registry. High school students can be hired to do work formerly reserved for university graduates. By nucleating a social-material arrangement, the form supports the conditions that give people the opportunity to survey and get to know the creek in their neighborhood.

Because many of the surveyors had little or no previous experience in the creek, the creek now exists for more individuals than it did before, and it exists in and of the qualities that they have inscribed on the sheets of paper. These individuals are more aware of the scientific indicators of water quality and have taken time to note features like what kind of rocks make up the creek bottom and whether there are logs in it. These observations are also tied to value judgements, which are based on scientific theory. Large woody debris in a creek bed is good; boulders in moderation are good. They become able to talk about the stream with others: “the creek needs more logs here.” “wouldn’t a riffle go well over there?” The stream becomes an entity, with its own needs and desires. The social-material relations of the municipality become transformed to include this scientific creek. Forms, volunteers, creeks, databases, government policy, scientific practice and many other elements begin to connect, to create new spaces and events, and a new set of arrangements begins to be included within the rural landscape.

In summary, the material transformation of the creek has been described, and its utility to the activists detailed. I highlighted the transformations that the form enables and noted that this involves a movement of scientific expertise in a direction from labs to field. I also advanced the observation that thinning allows the creek access to spaces that it never had before and allows many individuals to participate in creek surveying. This final note about participation was elaborated as a confluence of the agency of field assistants, the forms, and the agency of the activists to produce new connections within the patchwork landscape of the community. These inscriptions were circulated (put to use) to funding agencies, community bodies, or newspapers. In the following, I outline the trajectories of four different inscriptions produced by the activists. Two examples come from a proposal to improve the creek and its setting in Community Park. Another example was culled from a grant proposal written to seek funding for a water-monitoring

project and the last from a submission to change the community's master by-law, the Official Community Plan (OCP).²⁸

From Inscriptions to Insertions

[WMR – start]Through the work of the activists and their helpers, Gordon Creek has become re-presented in many ways. The “true nature” of Gordon Creek, however, is not available in any one of these re-presentations, nor in any sum of them. But the activists mix, layer and insert different representations into documents such as grant proposals to support some argument, some request for further funding, or some local planning document. The proposals are full of inscriptions (visual re-presentations) such as maps, photographs, icons (fish), tables, diagrams, design plans, tables with measurements, or aerial photographs that function as maps.[WMR – end] The creek is not one but different things at the same time, and by producing different representations, both scientific and less scientific (more anecdotal), the activists can support the material transformation of their designs into boulders sitting in the creek.

One way of considering these re-presentations is taking them as examples of pedagogical work. The activists both present (as in the case of inserting ecological discourse into the OCP) and interpret (as in their flexible use of photographs) representations for their audiences, tailoring the presentation to that audience's concerns and imperatives. They take care not to let the indicators of water quality stand alone, but to interpret them, both in terms of what the numbers mean, and what action to take as a result. The activists are educating the people with whom they are interacting.

The flexible pedagogy of translating these representations is a reflection of the activists ability to work in different political spaces and the necessity to fit into the relations that make up these different spaces. Whereas government publications maintain an authoritarian tone regardless of the audience, the activists need to produce their texts such as to adapt and join into the different concerns of the community. The activists strengthen their position in the community by making their arguments relevant to the

²⁸ The OCP is a planning document that sets out a community's commitments. Any new by-laws enacted by council must be consistent with the Official Community Plan. It is a democratically negotiated document, which is updated about every 5–10 years.

concerns of that community. The activists thereby increase the number and robustness of the connections that they can draw on, and make themselves bigger, that is be present in more spaces, or as mediators between previously unconnected patches.

2 for 1—Same Picture. Different Pedagogies

To illustrate the flexibility of the activists' interpretative skills, the same photograph is examined as it appears in two proposals, one requesting municipal approval to do work in a local park, and the second requesting money to fund a 'water budget' project (Figure 2, next page). Both proposals were successful. [WMR – start] Photographs are ambiguous re-presentations because they give both an impression of realism and, at the same time, need instructions to be read so that what is important can be taken from them. They are re-presentations that still contain much of the messiness of nature that impede easy classification. The activists use the complexity of the information in photographs to create different compelling messages from the same image: that is, they use different pedagogies. In the following case, a photograph in the proposal for in stream work through Community Park shows a straight watercourse with no overhanging trees or bushes surrounded by barren fields (figure 2a). The sense of barrenness is heightened by vertical pipe made from corrugated steel rising from the creek in the foreground. Captions and main text read:

CAPTION: 'Channelled segment of Gordon Creek upstream of Community Park'

MAIN TEXT: 'In the last hundred years, the wetland was drained and Gordon Creek was channelled for approximately 2000 m through the flats (Figure). These flats are subject to annual and flash flooding due to a combination of natural drainage patterns and changes in hydrological conditions such as increased storm water runoff from impervious surfaces higher in the watershed' (Henderson Creek Project, 1998, p. 8).

Tables, containing indicators from the water quality assessment taken near the channeled area of the stream, follow this photograph. These tables show that this reach has the poorest water quality of the three reaches within the park. In this case, what the reader is to learn is channeled by the creation of a compound image of the creek (layered representations): tables, text, and photograph combine to establish 'poor water quality'. [WMR – end] Juxtaposed with this photograph is another photograph showing a section of the stream overhung with lush vegetation, where the clear water trickles over a gravelly creek (fig. 2b). Text and tables support their statement that this area, downstream of the park, represents high quality trout habitat. In this proposal it is important for the activists to establish that there is a water quality problem in the park, and to establish the relationship between poor water quality and the surrounding habitat. Their intention in the proposal is to get municipal support to enact in-stream and bank-side changes. These changes will increase the water quality and alter the surrounding bank areas to make them look more like the creek banks bordering the "good quality" water. Thus in their proposal, they teach the municipal councilors how to interpret habitat features in terms of water quality. By instructing them in this practice, they stand to gain the councilors' support for their proposed plans.

[WMR – start] The ambiguity of photographic representation allows the same photograph to be used in a quite different context with a different pedagogy. Here, in a grant proposal for funding to do more water monitoring work throughout the watershed, the focus is on what appears to be a pipe rising out of the Creek in the picture's foreground.

CAPTION: 'Hydro-metric station on Gordon Creek (south arm of Henderson Creek) measuring continuous stream discharge'.

MAIN TEXT: 'Discharge measurements are generally 6 to 10 times greater at downstream site than at a flume site. The downstream site, a water survey station on W. Farm is roughly 2km below the flume site on the Goodwin Farm. In between these sites, 7 small tributaries feed the main creek, yet there is negligible flow in them during the summer period. The inflow is believed to be due to the influence of the nearby bedrock aquifer just to the north of the valley. Bedrock is observed to form sections of the main streambed'. (Henderson Creek Project, 1999, p. 3)

Inserted into a different proposal, the same photograph is used to point to the engagement of local people in measuring water levels. This interpretation constructs the vertical pipe as a monitoring station, which serves as a positive aspect, reflecting valuable activities that are already taking place. The pedagogy here is seeing the pipe as an instance of community involvement and prior work in the domain (“Our data gathering efforts to date include...”), which is worthy of continued funding. In this, the activists’ pedagogy is not unlike that enacted by police officers as they provided readings of videotapes during the Rodney King trial (Goodwin, 1994). In both our and police officers’ cases, the principal agents assist others, less familiar in reading images, to make salient those events that stick out in professional vision from the large amount of ‘gratuitous’ detail that come with images. Our activists, in their pedagogical activities, domesticate and control the very detail that provides their images with realism.[WMR – end]

The activists also use everyday similes and metaphors to help the readers who may not be interested in “% boulder and cobble” or “total dissolved solids” to understand the representations they have made. In the following example, again taken from the proposal to do work in Community Park, they explain the importance of the results of their fish trapping and electroshocking²⁹ work. These surveys showed that there are few trout living in Gordon Creek as it flows through Community Park. With the use of a simile familiar to many of us, they tell us what this result means. They also go further—they use the simile as metaphor to organise many different representations into a coherent overall view of the watershed.

Trout as Canaries

To symbolize the plight of the whole watershed, the activists use the creek’s resident trout population, estimated by live-trapping fish:

Trapping through the park has failed to note a significant presence [of cutthroat trout].(Henderson Creek Project, 1998, p. 9)

²⁹ Electroshocking is an accepted method of counting how many fish are in a small area. A registered electroshocker inserts the tool into the water, and delivers a charge that stuns the fish without killing them, allowing them to be seen and enumerated.

Similar to canaries in a coal mine, the cutthroat trout serve as a good indicator of overall creek and watershed health. If the trout are suffering as a result of water quality and quantity problems, this indicates the creek is being negatively impacted by human land use activities.³⁰ (Henderson Creek Project, 1998, p. 9)

Canaries were taken into coal mines because of their sensitivity to poisonous gases (Kentucky Coal Mine Museum, 2000).³¹ That is, the birds would die before the gas levels became toxic enough to affect the miners, who could then escape in time (B. Gothard, private communication, 7 September 1999). If we take the simile “like a canary in a coal mine” to indicate the situation in the creek, then the decline in trout population tells us that there is something wrong with the environment, something that is presently undetectable and potentially lethal to us. The simile thus transforms the collection of representations of “stream water quality” (which residents do not drink) or “fish habitat quality” (which does not affect residents’ daily lives) into an urgent health issue, one that the municipality would be unwise to ignore because the gilled “canaries” are dying. The simile is used to bridge the gap between scientific representations about a world “out there” and the daily lifeworld of the watershed’s residents.

The trout are also transformed. No longer are they merely slim fish living among the logs and boulders of the creek, but they take on the role of indicators of stream and watershed health. The activists use this re-framing to create an iconic trout, a symbol of their project, standing for stream, watershed and community health. This trout shows up on their signs, on their brochures, in newspaper articles and on their logo. In fact, the activists are known among members of the farming community as the “fish people.” The fish, connected to community health through the “canary in a coal mine” simile, is the symbol through which the Project interacts with the public. It gives them a place within the daily lives of the residents: they are people working toward the health of the community, not just people concerned with sedimentation, benthic invertebrates,³² and riffles.

³⁰ Henderson Creek Project, web site, ‘about page’: Why is the Health of Henderson Creek Important?

³¹ These include, according to the Kentucky Coal Mine Museum, methane and ‘black damp’ a colourless, odourless gas which is an ‘instant killer’.

³² Benthic invertebrates are insects (usually larvae) that live in the creek and are the major food source for young trout.

The juxtaposition of photographic images, tables, measurements, water quality, habitat assessments and metaphorical relations to the municipality's health worked. The municipality granted the activists the right to modify the creek in Community Park. The Henderson Creek Project was now recognized as a legitimate group, authorized to negotiate directly with the park manager and take action to modify the creek and the areas of the park close to it. There was a new "discretionary space" (Callon & Law, 1995) in the municipality. The park manager, Brenda, now needed to learn about stream ecology and the concerns of this new entity on her desk and flowing through her park. A new discourse had begun and a new creek was about to be made.

Through employing standardized scientific practice and transforming it into a new blend of argument, the activists were able to obtain permission to begin altering the creek in a way that would be consistent with the discourse of stream ecology. They rearranged and mixed scientific with more everyday means of representation to create a new argumentative space in the municipality, and from that new space, were successful, with the help of the inscriptions, in creating new bureaucratic space through the support of the municipality. Thus science had been conscripted to serve a community group working for the common good. In this sense, as a "servant for the people," it has helped shape and has determined the results of a democratic process. In the next section, I follow how the activists then used this new set of arrangements to expand their reach into the community and to physically alter the creek.

Trojan Horses—Inserting Ecological Discourse into Community Planning Documents

Before I continue on with the Community Park narrative, I present one more type of use to which scientific discourse was put. Here, the activists lobbied the municipality merely to insert ecological discourse into a by-law. This new text, inserted into the Official Community Plan was intended to destabilize the portrayal of the creek by the engineering staff as one part of a storm drain system. There was no pedagogy involved, for there was only an insertion. But this insertion works in a different space, that of future councils and conflicts.

The Water Task Force (on which all three founding members of the Project served), a municipal committee charged with developing long-term solutions to the

various water problems faced by the municipality, requested that the Project comment on the Official Community Plan (OCP), which was being ratified that year.

The Project's submission to Council was in the form of a letter, outlining changes to the wording of the plan in sections dealing with environment, utilities, and long term vision. In this case, they did not make use of metaphorical language or "point out" things to the reader. They simply suggested that the terminology of stream ecology be incorporated into the appropriate sections. The following example comes from the "Utilities" section of the OCP:

OCP:

The existing storm drainage system consists of 28 separate drainage basins incorporating a variety of enclosed storm drains, culverts, open ditches, creeks, ponds and flood plains.

The system, in general is in good operating condition. The District conducts routine annual maintenance... Ongoing assessment of the storm drainage system will be necessary as development occurs. (Oceanside draft OCP, 1998, p.56)

Project's suggestion:

A statement/policy is needed that shifts maintenance of storm drain ditches toward managing all watercourses for improved diversity, complexity and stream function. (11.1.5) (Henderson Creek Project, 1998b)

The municipality has characterized its drainage profile as consisting "of 28 separate drainage basins," and includes storm drains, culverts, creeks and ponds as part of its drainage system. This system undergoes "routine maintenance" and seems to be in "good operating condition." The official wording constructs the drainage of the land of Oceanside to be a result of a number of separate, equivalent parts, which require ongoing maintenance to operate effectively. The waterways of the Henderson Creek watershed (and the two others within Oceanside) are not characterized as interlinked, which many of them are, nor are any of their other important roles (to other life forms, to other human uses) mentioned in the text. It is as if they were parts in a huge machine, which non-problematically "functions" as long as it is routinely maintained.

The activists realized that the ecological aspects of the stream are completely absent in this portrayal. This means that when making decisions about the watercourses,

ecological aspects would not enter into the discourse. In their letter to council, the activists suggest that these ecological aspects be inscribed as “improved diversity, complexity and stream function.” In this case, they advocate the insertion of ecological terms into a text where they were previously absent. The creek is presented in the decontextualized terms of an ecological textbook. In this political situation, this thin terminology, with its flexible interpretability in terms of policy implementation is the most appropriate. While discussing the wording to be chosen, much care was taken to choose scientifically robust terms that did not have immediate implications in terms of policy. The activists wanted them conventional enough to withstand scrutiny should a conservative council be elected, but strong enough to be used by a “green” council, or a well-organized citizens’ group to argue against ecologically damaging development.

I call these insertions “Trojan Horses,” because although they seem innocuous and based on ecological tenets, the effects of inserting and taking them seriously go well beyond the scientific discourse actually inserted. For example, an open ditch whose need for complexity is taken seriously is no longer an open ditch, but a watercourse full of boulders, logs and associated debris jams, which may well not function as effectively in draining the land. This transformation of a drainage ditch might have significant effects on the farming practices in the watershed and may have serious economic consequences. Thus the insertion of “respectable” scientific discourse can conceal contentious debates about how to co-exist with the landscape.

These pieces of ecology were inserted to do work in the future, to protect the ecological creek in the long term, to be used as a tool for champions of the environment who had not yet shown up. The activists, in this case, use scientific discourse to construct arrangements for what may be, to affect a social-material world that is distant in time. The thin, flexible and fluid text makes it possible to have such impact in the indeterminate future.

In the section above, I described but some of the transformations the creek undergoes in the process of thinning—turning a messy wet stream into columns of numbers, metaphors and arguments. I pointed out that through this thinning, through the decontextualization of the stream and its articulation into scientific discourse, it actually became “weightier,” transforming into a more powerful argument in support of the

activists' plans. In the next section, I focus on the activities that bring ideas and design plans back to the physical creek—the transformation which representations undergo in order to return to the world of objects.

Restoration as Design

Much of the activists' work involves rehabilitation of the stream that flows through their watershed. This work is informed by ecology, and is formally called ecological restoration.³³ The Henderson Creek Project promotes a philosophy of restoration that attributes to the creek the knowledge how to repair itself. Given time, space, and materials, the activists expect the creek to heal itself. They explicitly frame design objectives as strategies of assisting the creek. For example, one of the activists' design objectives is "to augment the process of self-restoration with some initial materials (logs, rocks and gravel) and to stop the continuing external damage to the riparian areas and the banks" (Henderson Creek Project, 1998a, p. 14). During the course of the research, I came to understand their activities less as a return to a past, as implied by the verb restore, but rather as constructing a stream that conforms to what is considered by restoration practitioners to be a healthy stream. Despite the activists' claims that they "believe that the stream knows how to heal itself" (Henderson Creek Project, 1998a, p. 14), I consider their restoration practices as a work of agency distributed amongst the activists, the creek, the community and the tools, instruments and inscriptions they used. Human agency is a key component of restoration work, and includes a future-oriented temporal vision through the metaphor of design. By adopting this approach, the confounding rhetorical issues of "If nature can heal itself, why are we attempting to control it by introducing changes to the landscape?" and "What time period do we restore it to?" (Higgs, 1998), which are common in the restoration community (BC Environmental Network, 1998) are sidestepped. The notion of restoration as design also enables the researcher to treat the activists' diverse activities, whether changing the Official Community Plan, surveying a creek or hosting an open house, as part of a

³³ Ecological Restoration is defined by the Society for Ecological Restoration as "the process of assisting the recovery and management of ecological integrity. Ecological integrity includes a critical range of variability in biodiversity, ecological structures and processes, regional and historical context, and sustainable cultural practices." (Higgs, 1998, p. 35).

coherent framework – the practice of re-designing the social and material relations that constitute their community.

Re/Designing Henderson Creek

I have traced some of the relations and activities involved in thinning the creek from a multifaceted, moving, wet body of water into a set of inscriptions connected to distant centers of power, that travel to them and transform sets of relations there. Continuing along the narrative, I now focus on the process by which the activists first designed, then enacted amendments to a riffle, the first material structure they designed and built in Gordon Creek. This “thickening” of inscriptions involves a whole different set of actors and practices than the previous work of thinning the creek did.³⁴ I highlight the different, often ephemeral and flexible ways that the riffle or parts of it were represented as people began transforming inscriptions through working with the landscape to bring material logs and boulders into place. Here, inscriptions play a smaller role in re-presentation and embodied gestures and relations of simple signifiers like flagging tape within the creek bed come to greater prominence. The narrative emphasizes their importance in the organization of an activity system, in this case the modification of a stream. Non-humans and their capabilities as well as environmental factors like weather, season, and time of day are also important in shaping the set of relations the Project volunteers put in place. The modifications they install, as simulations of natural landscape features but also as representations of scientific theory placed in the stream for clearly defined reasons, have a unique social-material place in the community. Like experiments, they are creations borne from scientific theory and practice, but they have a number of other features that highlight the tenuous nature of the place restoration-based change has in a community. They depend on a certain interpretation for their longevity and for their full function in nature. Yet the activists do not have the rhetorical means to restrict the interpretation of their work, as they did in the grant proposals or scientists do

³⁴ We use the term “thickening” here to indicate both the gross material changes that occur as sketches become transformed into logs, and the practices and actor-networks necessary to re-situate and materialize theory-laden discourse (Alder, 1998).

in professional journals. I argue that it is an important problematic for the activists to maintain the social relations of their material creations.

Inscribing the Riffle

The narrative begins with a walk in the forest by several stream biologists on whose expertise the activists regularly draw. The biologists' interpretation of the creek, its potential and its needs led them to suggest that the addition of riffles to the streambed would be good for its health.

[WMR - start] In her proposal to council for their approval for in-stream work, Meaghan includes two re-presentations of riffles. One of the re-presentations is a technical drawing displaying general design principles, which the activists copied from a textbook. This can be seen in Figure 3a. In this, the first appearance of the riffle, it is a generic riffle, standardized, with no reference to any of the salient features of Gordon or any other creek.

The second re-representation of the riffle is within a map in which two types of inscriptions are layered (Figure 3b). The first is a basic line map that traces the length of the creek, the park's boundaries and the property lines of all adjacent landowners. Layered onto this map are re-presentations of standard riffles at the specific sites that seemingly suggested themselves to the biologists during the walk. This second re-representation layers more information onto the standard riffle, namely, where in the park the technical advisors think appropriate sites are located. [WMR - end] We are that much closer to building riffles on site.

When the proposal was approved, the Project had enough time and money to build the large riffle in 'Reach 3' of the creek in the park before the fall rains began and made in stream work impossible. The next year, the Project introduced some large logs into the pool that had formed behind the big riffle installed during the previous year and built four smaller riffles upstream of it. The following section analyses some of the work done that second fall.

Figure 3. (next page):

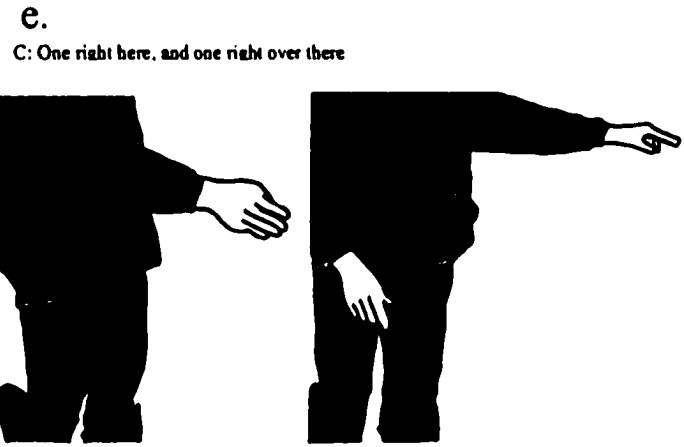
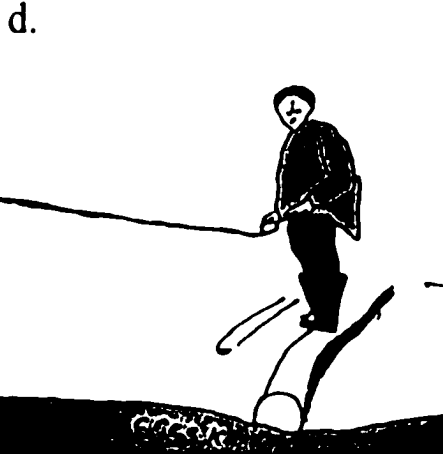
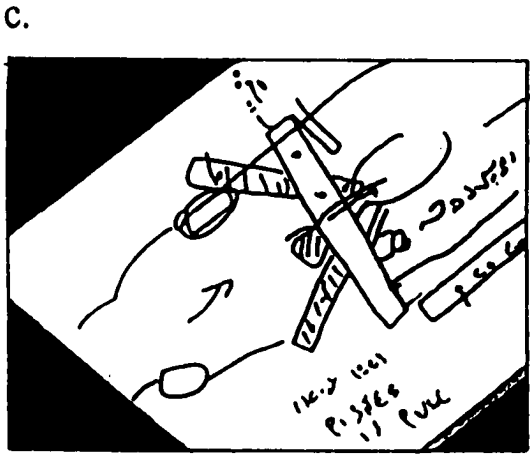
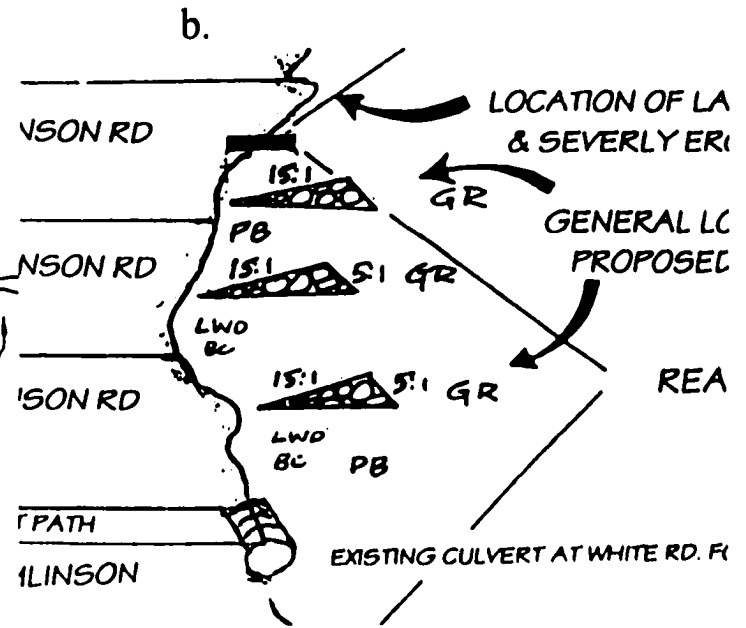
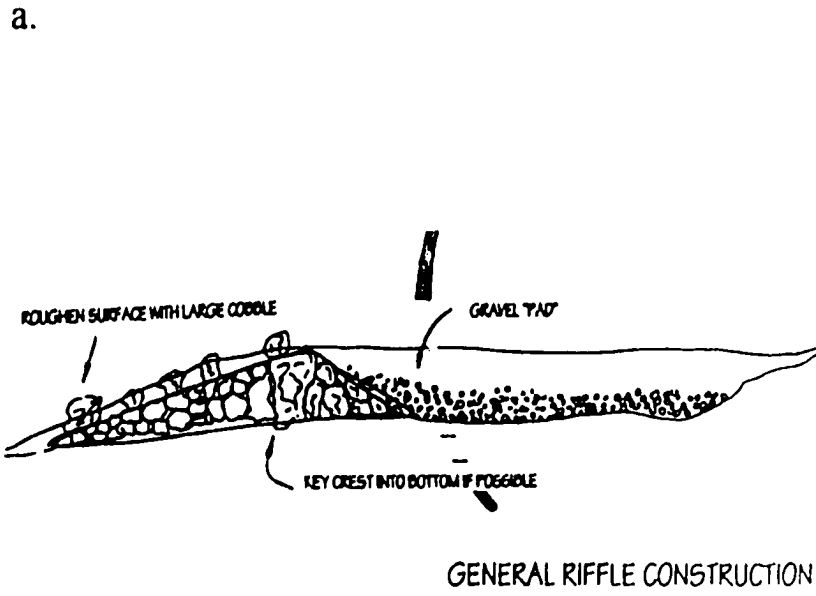
a. One representation appropriated by and circulated within the activist group. In this form, the future riffles were presented to Town Council. It also constitutes a description of the embodied skills among the activists, one of whom has already constructed a series of these structures.

b. The map resulted from the walk along and through the creek in Community Park. This inscription actually results from the layering of previously existing inscriptions, a map, and the iconically represented riffle design in Figure 3a.

c. Shown is the facsimile rendering of a camera shot during the design meeting between the consultant Colin and two activists (Stuart, Meaghan). Proposed enhancements to an existing riffle are sketched by Colin in a waterproof notebook.

d. Shown is the facsimile rendering of a camera shot during the design meeting between the consultant Colin and two activists (Stuart, Meaghan). Here, Colin is shown at the end of his walk through the creek to the position where the butt end of the central tree (Figure 3c) is to be positioned. The string is one of the embodiments of the redesign.

e. In this facsimile rendering of a camera shot, an aspect of the riffle redesign is literally embodied. This representation requires listeners to disclose meaning from the interaction between the approximate spots pointed to and the affordances provided by nature in the setting.



The Ephemeral Riffle-in-Setting

We are familiar with the re-presentation and circulation of natural features on paper. What kinds of re-presentation are used in the translation of these paper re-presentations to actual physical objects? In this section, I pay particular attention to the ephemeral re-presenting involved in the design of the riffle-in-the-world. It is at this stage that the theoretical discourse of ecological restoration comes into contact with the actual site to be modified. This is where the co-presence of environment and people lead to the emergent co-design of the in-stream modification as it will appear at a specific site. Much of the re-presentational work is verbal and gestural in nature. The activists layer these ephemeral and expressive re-presentations on the durable, mute materiality of the streambed. This work prepares what was once just a creek running through a park into a site ready for a very specific transformation.

Colin, the consulting biologist, is a long-time associate of Meaghan's and had helped with the design and construction of the riffle a year earlier. He had walked the stretch of the creek the day before and produced some notes about potential design changes (Figure 3c). [WMR - start] This morning, as Meaghan, Stuart and Colin are standing next to and on the riffle, these notes and the landscape become referents for the ephemeral representation of design. Colin suggests that the activists construct an A-shaped structure in the pool that has formed behind the riffle. Two logs are laid on the creek bottom as an open-ended V, and a large cross-log is laid on top of the two supporting logs (see Figure 3c). This structure will encourage scouring of the pool bottom, removing silt and exposing the gravel that is essential for the trout to spawn. Stuart and Colin design the location and length of the main tree trunk that is to overlay the two supporting logs. Although Colin has a design drawing that includes the existing riffle and the changes to be made, it is not clear where and how the design is to unfold in its material embodiment. In this episode, they physically position themselves in a way that, together with the hip chain,³⁵ become embodied forms of the design in the world.

³⁵ A 'hip chain' is the same instrument Latour described as a 'pedofil' or 'Topofil Chaix™' (Latour, 1999, chpt 2, p. 43). A spool of fine string is affixed to a counter inside a housing. As the spool unwinds, the counter records the distance of string that has just been unwound. The 'hip chain' is affixed to the

Stuart and Colin move to opposite sides of the creek, which has formed a wide pool behind the riffle, and come to stand at positions taken to be the butt ends of the central log. After temporally situating themselves, Colin directs Stuart and moves himself until both stand in a way that is “right there” and therefore “good.”

S: Right here?

C: Yeah, maybe just a step over

S: Alongside the log here?

C: Right there that’s good.

The design for the position of the logs emerges from the interaction of people in the setting. As a result of their activity measuring and adjusting their position, the hip chain comes to take a certain orientation with respect to the landscape. This orientation (Figure 3d), and the associated distance, become important markers in the design. At this stage, the design is not just paper work, but has been moved into the world. Yet it is not design with the materials that ultimately will constitute the finished design. Rather, the string is taking the place of the log, reducing the physical load on the designers. They can adjust the design until it feels right, until Stuart’s position is ‘good’.

Colin and Stuart begin positioning themselves, the hip chain’s string stretched out between them. Colin reads of the length of the string uncoiled from device. Stuart asks him about that.

S: How much is that?

C: Ideally it would be about 8 meters

S: Eight meters.

M: So the one going across would be 8 meters?

C: Yeah.

surveyor’s belt, thus allowing her to measure how far she has walked from a fixed point without using her hands to carry any type of measuring apparatus.

In response to Stuart's question, Colin brings in another representation, '8 meters length'. Meaghan, who takes notes throughout the episode, as she will be responsible for managing the redesign of the riffle, reconfirms (with Colin) that the 8 meters represent the length of the log that goes straight across.

In this episode, a number of translations occurred. At first, Colin walks through the creek to the butt end of the future tree; its position embodied in the ephemeral trajectory of the walk across. While walking, the string from the hip chain unfolds, positioning itself in nature as a representation (direction, length) of the future log. In both direction and position, the string is an iconic representation of what is to come. The hip chain device translates the length of string pulled out, which is analogue representation, into a digital representation, 8 meters. Colin can then read this translation and communicate it to Stuart and Meaghan, who inscribes it into her notebook. Later, this inscription, read and spoken by Meaghan, will serve to direct the efforts of a volunteer with a chainsaw, who will cut the log to length.

Colin also re-represents (besides drawing and indicating with the hip chain) how the logs have to be positioned by gesturing (ephemeral) towards some place in and next to the creek (Figure 3e). Here, the future log exists in and as of its butt ends, the potential positions of which Meaghan and Stuart have to infer from the gestures. Although gestures are often indeterminate in cases where they point to places removed from the person, Meaghan and Stuart can elaborate where 'here' and 'there' are, because not every place in the setting is equal. The meaning of 'here' and 'there' unfolds for the two listeners from the proximate positions that their regards are directed to, and how these areas offer themselves in terms of affording logs to be placed.³⁶ Paraphrasing Goodwin I might say that the activists and their consultants do not deal with the position of the logs as an abstractum (as this might occur in a book on the theory of building such structures) 'but instead as something to be defined indexically—that is to say, with reference to something else'.³⁷ [WMR - end] Ephemeral, indexical work such as just discussed is very

³⁶[WMR] Here, affordance is understood as coined by J. J. Gibson (1986), a constraint that decreases the interpretative flexibility and makes some actions, meanings, more likely than others.

³⁷ The coordination of talk, perceptual structures in the setting, and gestures is a pervasive phenomenon in many different settings. Charles Goodwin has conducted a number of seminal studies in this respect. See Charles Goodwin (1994, 1995).

important in the transformation of 'thin' representations into thick objects. Since the participants are enacting theoretically informed practice while situated where they will carry out the work that is described, this 'invisible' stage is a crucial step to shifting the location of the relations of scientific meaning from pieces of paper read in offices to creek beds.

Creating Hybrid Spaces

I have just shown that much of the re-presentational work done in re-situating re-presentations of in-stream structures is ephemeral, that is, it leaves no trace. I noticed that the activists used multiple signifying systems in order to ensure that the decisions made during the consultation with Colin informed the actual placement of material during the building of the new structures. Thus they created hybrid spaces, a term coined by Goodwin to denote "spaces as locally organized, historically situated practice" (Goodwin, 1995, p. 265).

At the end of the day, the activists have walked the entire length of the stream in the park with Colin and he has outlined detailed prescriptions to at least nine sites. The creek-to-be has been represented through his speech, gestures and drawings. To help these ephemeral re-presentations last for the two weeks between his walk and the volunteers actually doing the work, Colin and Meaghan have translated his instructions into durable material forms. Meaghan has made a rough map and taken notes, which include logistic details such as how many yards of gravel to dump in the creek. Ferns on the stream bank are adorned with pink and orange flagging tape, with numbers written on them in black marking pen. An orange length of tape, which means a riffle-structure, has "1/2 yd" inscribed on it, which indicates how many boulders to lay down. Piles of rock are placed into places approximately equivalent to the sites indicated on Meaghan's rough map. And finally, the material changes are also re-presented within the bodies of the people involved. We remember the experience of being at a certain site and cue from landscape features like a sharp curve in the stream to remember what Colin had said.

Unlike previous work done by the activists, much of the re-presenting is done not by forms or photographs, but by durable structures in the streambed, and the experience of being-in-the-streambed is a crucial aspect to their agency. At this stage, the activists

have used many different resources, pen and paper, gesture and speech, labels in the environment, to prepare for the building of new riffles. They have translated their in-stream structures into a social and material hybrid located both in the bodies of Meaghan and Stuart and in the actual streambed. These re-presentations have functioned to insert the materials and space of a creek bed into a historically situated, ongoing practice, the restoration of the Henderson Creek Watershed.³⁸ The next stage of this practice is to use the hybrid space to orchestrate the material thickening of the design plans. Logs will be logs, cut from a farmer's downed oak tree, not just a length of fine cotton twine or a piece of flagging tape.

Another Round of Representation—Into the Community

The materially thick transformation of the design plans does not just entail a retracing of steps along a chain of representation, going back from less to more situated, but rather, employs entirely new networks of actors, both human and non-human. The creek and their design plans are re-presented to businesses, residents and park managers in attempts to solicit both volunteer help and inexpensive materials. The activists' agency becomes distributed more broadly throughout the community; and the riffle and the ecological creek become known by more people.

Re-presenting the Project and the work they want to do is mainly Meaghan's task, and much of her success relies on her ability to persuade business owners that the Project is a serious undertaking that is doing something good for the community. This kind of representation is done mainly verbally, over the phone, contacting the local businesses, stating what the purpose of the Project is, and asking for what is needed. In these interactions, she often relies on scientifically grounded discourse. She portrays the Project merely as performing scientifically justified stream restoration, to make it healthier for the fish. The connections to human health, development and overall watershed management are left out of her discourse. In this part of the world (Pacific Northwest), many people understand the importance of restoring fish habitat due to the local crisis with salmon populations so the words "fish habitat restoration" have a

³⁸ For more a detailed explication of the many convergences possible in hybrid space, see Goodwin (1995, pp. 265-268).

meaning to many people, and they are willing to help. In this set of relations the Project is involved in politically neutral, scientifically justified, good work, helping to rebuild the environment.

As in other situations the Project had been involved in, local businesses supplied materials at cost or less to help build the structures. An arborist donated two truckloads of live poplar logs (important for shoring up eroding banks) for free. A farmer donated the transportation of a few tons of oak logs. The park foreman donated equipment, storage space and the time of some of his employees. A local John Deere™ outlet donated an all terrain vehicle for a day along with the operator. The Project's agency expands like the creek after a hard winter's rain, swelling to include many community members, bringing material change to the landscape. I argue that this as another aspect of democratic science, where the material work to be done is shared throughout a community and the ultimate form of the structures is an embodiment of the efforts of the various members who participated.

And into the Material World—Human and Non-Human Mediators

Now all the actors are in place. Like the music amateurs in Gomart and Hennion (1999), Meaghan and Stuart have prepared for an event in that will arrive and manifest itself well beyond the bounds of their personal agency.³⁹ In the following section, I focus on the contributions of the non-humans and the durable materials that reside in the creek, emphasizing how they contributed to the translation of the design plans into structures in the stream.

A hybrid collective of human and non-human volunteers performs the modifications. Although many of the human volunteers are the same bodies who do surveying work, this set of non-humans are not the same non-humans who helped to thin the creek. There are no meter sticks, surveyor's tripods or hip chains. This second group of non-humans are selected to help move material. Trucks bring logs to place in the stream as cover for fish and Bobcat™ tractors move boulders and rocks to be used in

³⁹ Gomart and Hennion (1999, pp. 242-5) write of the meticulous preparation involved in setting the conditions for an event in which the person abandons a large degree of control.

riffle constructions into place along the stream's length. Chainsaws and drills prepare logs to be fastened into the streambed by means of Rebar poles, which are pounded into the ground by post-drivers. These different non-humans help the humans perform a different kind of activity, that of bringing physical, durable changes to the creek.

At this final step in the embodiment of the design plans, the individual affordances and constraints of the non-humans contribute to the final thickening of the design plans. For example, the final construction of the proposed A-shaped modification to the riffle was about 10 feet upstream from where Colin and Stuart had designed it to be, because the winch could not pull the cross log any further. The limits of the conscripted non-human, which was a function of the community from which the activists could draw resources (they didn't know anyone with a stronger winch), overrode the theoretically correct placement of the log. Also, the shifting conditions within the environment itself needs constant interpretation and response. "How much work can be done with the amount of daylight left?" and "Will a log need to be fastened in this spot, or can it just be wedged in?" are the kind of questions that arise and need to be addressed. At a site like this, many non-humans combine to shape a structure's final form.

When directing the placement of materials, Meaghan consulted Stuart, who was also present when Colin suggested their placements, her notes, a map that she constructed based on her notes and the flagging tape Colin had put on the stream bank. This collection of sources is not just redundancy of information, but a collection of re-presentations in multiple domains,⁴⁰ verbal (Stuart), physical/spatial (flagging tape in the landscape) and inscription (maps and notes). In performing the structures, Meaghan had taken care to create a hybrid space, a network of re-presentations of the creek-to-be. Each of these re-presentations had a different kind agency. Stuart, remembering what Colin had done at this spot was different than flagging tape on a log. Thus when it came time to enact the physical changes, she could draw from these diverse agencies in order to construct the structure that had been intended.

In this section, I considered the building of in-stream structures as a performance, and described a number of features or stages of the process. The activists re-situated their

⁴⁰ For an elaborate treatment of this type of 'spreading around' of cognitive function, see Edwin Hutchins 'How a Cockpit Remembers Its Speed' (Hutchins, 1995b).

thin designs through embodied work within the space they were planning on transforming. With the help of a consultant, they enacted practices of stream ecology. Through re-presenting the theoretically informed decisions as discourse indexicalized to the space, taking notes, making diagrams, placing situated markers in the environment, they created a hybrid space, which could function to help structure subsequent actions on an emerging construction. They worked to persuade a different set of actors than had previously participated in the stream's thinning to help with the material thickening of the design plans, distributing their agency more extensively throughout the community. Finally, they orchestrated the confluence of different humans, non-humans, and environmental factors in a performance supported by the hybrid space they had previously constructed. This performance resulted in material modifications being made to the stream, the thickening of their plans.

Creating a Durable Material Thing amidst an Ecology of Social Relations

I have just detailed some of the social and material interactions involved in the translating of new in-stream structures' identity from ephemeral and thin re-presentations to physical structures made of durable materials. The activists now work to build a new set of social and material relations to make the structures themselves durable.⁴¹ Durable in the sense that, as rock piles, they are likely to stay in place, not dismantled by vandals, and in the sense that, as elements in community discourse and concern, they are connections back to the ecological creek.

The Project has a number of strategies for achieving this goal. It is able to maintain some surveillance, as a steering committee member walks his dog through the park everyday. Thus he can interact with people he sees tampering with the creek, and more importantly, inform other Project members if some damage has been done. To assist the structures and bank-side vegetation in establishing a durable existence, the Project also plans to introduce three social-material modifications. A fence at the top of the creek banks will discourage people from going down to the creek and disturbing it or the structures they have inserted. A new trail will replace the old one in an area where the

⁴¹ Reid Helford (1999) also writes about how activists construct, physically and discursively, new 'ecologically correct' entities.

trail followed the creek too closely. From this new trail, people can see the creek, but aren't close to it. The Project hopes that these two modifications to the landscape will act to stabilize the creek's banks through restricting people's access. These engineering feats are not merely of material nature but are also acts of social engineering. In presenting their plans to council, the Project takes pains to legitimize these changes in and to the community, and again, they draw on a variegated (scientific) discourse and associated representations to assist them in their effort.

The activists' riffle is subject to "weathering" and "wear and tear" in the social-material world. Different people will frame this new conglomeration of relations in different ways, and thereby mount new threats to its existence. For example, the farmers in a town council meeting may represent the success of reducing flow velocity in the creek as the disastrously lengthy delay in the draining of their fields. This may result in the removal of the riffle, and therefore, in the undoing of the Project's design work. Or teenagers may think that it is good to clean up the creek and remove the rocks. How does the riffle maintain itself in the face of the multiplicity with which it now interacts?

Interpretative signs along the fence help people understand what all the changes are about. They do the important work of translating the landscape changes into text, more easily interpreted by community members than the raw materiality of the riffle. Changes are thereby brought into the discursive world of the municipality. These signs, by identifying the Project as the author of the modifications, also increases the Project's presence in the community, for better or for worse, increasing the tangle of relations that connect the Project into the community.

The Project assists the riffle to increase its durability in other ways. For example, project members generate more ecological re-presentations, this time of the "healthier" stream. One year after the construction of the first riffle, project members electroshocked the pool behind the riffle and found many more fish than they had the year before. Thus began a new round of re-presentations—photographs of trout, an article in the local newspaper ("Cutthroat Trout Count Way Up in Henderson Creek" [Peninsula News Review, June 30, 1999]), and new claims in grant proposals. Once again the creek becomes thinned, re-presented by numbers and in ecological discourse. Using the trout as

an indicator of health, the activists support their claim that the interventions are working. The creek is becoming healthier thanks to the work the Project has done.

In the long run, though, much of the riffle's fate is out of the Project's hands. By constructing the riffle, Project members transformed an inscription into part of "nature," where it became incorporated into the natural cycles or processes of the area. Seedlings planted on the stream's banks change and transform in ways that no human agency can control, and the riffle will be dispersed by winter rains, the logs will rot away. These entities find their utility not only as objects for further representation and circulation, but as new useful things in the lives of many creatures and the function of biological cycles. As the objects move from a world entirely under the control of Meaghan, who sketches them out and layers them into maps, the re-presentation embodied in the objects is forgotten and utility is taken up by a myriad of beings. They become a useful part of others' (e.g., trout, mayflies and bullfrogs) daily life. They are designed to allow ongoing re-design and transformation by agents as diverse as winter rains and horse riders. In the end, the success of the riffle constructions is measured by how they become taken up and transformed by these non-human users and forces, and by how well they assist in reconfiguring these users and forces in turn.

So where does this position my narrative of thickening with respect to a democratic science? Clearly, as I have pointed out, the Project enacts practices that can be considered a democratization of scientific practice—they encouraged agency to be distributed and thereby allowed others to take part in authorship and construction. Through the results of this construction, a world beyond the demos is implicated, involved and affected. Perhaps we need to expand our definition of who this science is serving to one that includes animals and biophysical elements in it. Or, as Bruno Latour suggests, is this conglomeration of entities simply what it means to be human?⁴²

⁴² 'The regime of ecology simply says that we do not know what makes the common humanity of human beings and that, yes, maybe, without the elephants of the Ambolesi, without the meandering waters of the Drome, without the bears of the Pyrenees... [we] would not be human.' (Latour, 1998, p. 233)

Conclusions

This paper has been about the efforts of a grass-roots environmental activist group to bring about changed social and material relations within their home municipality. I argued that by travelling to different spaces such as schoolrooms and council chambers, thinned re-presentations of the creek shift the arrangement of social relations to grant the creek existence within the social material practices of those spaces. The process of thickening the creek from re-presentations to actual logs and rocks also involves many social arrangements and re-presentations of both the creek and the objects to be arranged. As new relations become crafted, agency shifts between different actors and, especially in the case of the in-stream fixtures, includes many life forms as well as the weather. The activists' work, put in place to transform a community, becomes itself taken up and transformed.

I also suggested that in the relations of the activists and the community, one finds features of a democratic science. The activists' diversity of translations of scientific discourse about the creek and their circulation insert science into local politics through multiple forums. They make scientific practice more available to a populace by including many volunteers and part time workers in their mapping and restoration work. And the results of this engagement show that there is no "pure" result that has gone according to ecological theory, but one that embodies the concerns and resources of the community, scientific practice itself is transformed by this democratization.

Questions arose as I wrote this paper, though. To what extent is the activists' science, which is still standardized by the provincial government, a truly democratic enterprise? What are the implications to the landscape and the streams when all that is recorded of them are their physical properties, and only those relevant to fish habitat? Whose stories are being left out, whose are being included and what is the significance that the tiny creeks of the province are becoming part of its bureaucracy? An aboriginal friend familiar with the situation in the Henderson Creek watershed brought out this point very clearly. Some of her friends live on the reserve through which part of Henderson

Creek flows.⁴³ After attending a presentation that I gave about this work on re-presentations, she commented:

The activists are doing the same thing that the farmers did when they first cleared the forests, drained the swamps and channelized the stream. They are perpetuating the dynamics of colonialization. They haven't taken the time to educate themselves through dialogue with the Coast Salish people who've lived there for hundreds of years and who probably have stories about the birth of the creek. They've spent a summer measuring it with their meters and yardsticks and now they've got their machines in there, changing it. They haven't taken time to build relationships with the people who first inhabited the land. I do not understand how this can be called a democratic process. (Patricia Vickers, pers. comm'n, October 25, 2000)

The Project had not adapted its social practices to include the aboriginal people on their own terms. I had never before considered the racism implicit in both the activists' actions and even their means of describing the creek. Her argument has helped me to understand that our claims and hopes for a science in the service of all is not an end game that will have its conclusion in a Utopian society in harmony with all its peoples and non-peoples.⁴⁴ It brings us back, away from our deftly argued conclusions, to the practice of working for change in the middle of a world with its limits, contradictions and challenges. Things are sloppy, done as best as possible, and constrained by networks of personal contacts and the agency of others. We can only be sure that things will keep shifting and transforming. And work to include as many good narratives as possible in the arrangement.

⁴³ In this part of the province, the First Nations people signed treaties with representatives of the Hudson's Bay Company, granting all the land to "the white people and their descendants" and restricting them to small parcels of land, called Indian reserves, surrounding their traditional winter village sites.

⁴⁴ Callon and Law (1995) echo our point in their critique of a liberal view among ANT proponents.

Chapter 8: Re-Mapping the Landscape: Science Educators within a Community Action Network

This piece was written in the summer of 2000 as a response to a call for papers from the journal "Perspectives in Education," announcing a special edition on the social, cultural and political dimensions of science and mathematics education. The specific question (given in the call for papers) that I addressed was: How can mathematics and science educators support non-formal and non-academic adult and community-based education oriented toward democratization and political action taking?

My answer, based on about two years with of fieldwork with the Henderson Creek Project, was to first re-define science educators to include all people helping each other do scientific activities in the community. The second move was, again consistent with my field experience, to situate schools in a supporting role, rather than a leadership role. From a practice theory perspective, this makes sense as schools and schoolteachers do very little science.

The intended audience for this piece consists of school-based science educators, so the theoretical discourse was kept to a minimum and simple terms were used to explain what I meant. This article's argument was grounded in practice theory perspective, drawing on the work of theorists such as Lave (1988, 1993) and Eisenhart (1998) who are concerned with learning per se as well as educational issues. A theoretical framework that emphasized an ecological (Cremin, 1976) approach to learning was adopted, where the multiple relations that support and constrain action are taken into account.

I used two field note accounts of singular events: the discovery and investigation of a fish kill in the creek, and the different types of scientific and non-scientific representations at a local event, "Oceanside Days," to structure my argument. There were videotape records of both events as well, though no video analysis was done. The fieldnote accounts were used as evidence for pointing out what I considered to be the salient features of science education within community action.

Thematic Issues

This chapter, like the first, is concerned primarily with science literacy. It also works to re-define what might be considered legitimate literate practice. In the chapter, the intimate relation between geography and knowing was emphasized. Knowing where to go to access resources, knowing where different people who can help you, live, knowing who owns what piece of land and whether or not you are allowed access are vitally important issues in community-based science. It also focuses on learning relationships. Who teaches what to whom, how people learn what they do in the field are components of literacy that become articulated. Through the analysis of a public poster session event, it is pointed out that science in the community is not as well bounded a practice as it is in universities, and educators do well to consider it as not separate from other endeavors.

Representations were less central in this analysis. In this iteration, they were treated more as aspects of a heterogeneous social landscape and as markers of the interpersonal relations in which they are embedded.

All these three aspects were discussed in light of how best to support a non-formal education that encourages local political action taking. Relationships, education, movement were all framed in the light of democratic action, of implied resistance. An egalitarian notion of science was proposed, and it was shown how who gets called the “educator” can vary with the situation and may have little to do with institutional assignments. This contribution to the understanding of science activity as supporting democratic process again emphasized the ability of local citizens, acting outside their official roles, to make effective sense of their communities, contributing to meaningful decision making.

The two vignettes in this chapter presage themes that are developed in much greater detail in following chapters. In the first vignette about a public presentation, notions of heterogeneous community reflected in heterogeneous representations are haltingly articulated. They become the central themes of chapter 9, “Science and the ‘Good Citizen’.” and are explored and elaborated in much greater detail there. In the second vignette, about investigating a fish kill in the creek, the movements and boundary

crossings which become the major focus of the final chapter, “Traversals.” are first treated. Through Cremin’s (1976) notion of the ecology of education, institutional arrangements necessary for the doing of local science are articulated. These, too, are more thoroughly scrutinized in the final chapter.

This paper, with its focus on the doing of local science amidst an ecology of relationships and representations, is unique in its focus on a specific question, articulated for an audience of science teachers. It is also a portent of what is to come in the following chapters. Here we see the beginning of style of analysis that fuses the study of representations, institutional analysis, people’s (and non-humans’) movement and relationship into a politically-informed discourse. From the perspective of having finished writing all these papers, the development of this analytic style is just as much a preoccupation of the following papers as are the development of the specific themes.

Re-Mapping the Landscape: Science Educators within a Community Action Network

Throughout the world, government control and regulation of science and technological development is waning. As a result, community “grass-roots” groups are often the final mechanism for democratic action taking in such areas as health care, clean water, and implementation of biotechnology. These issues are scientifically complex and gain complexity as they move from laboratories into the economic and political spheres of community life. People with scientific expertise are needed to help community groups, both through education and action.

Science educators have much to contribute. How can they be most effective? My ongoing research shows that science educators may be required to participate in unexpected ways in community-based activities. When science is engaged in the context of community based, democratic political action taking, it acquires a very different character from that which it assumes in laboratories, textbooks and classrooms. I propose that a radical redefinition of what it means to do and know science is necessary to capture its nature at the community level. In this chapter, I highlight and discuss several salient features in the activity of learning and doing science within the community situation, to encourage science educators in becoming effective participants in this complex, compelling environment.

Framing Education in Community Context

What is non-formal adult non-academic community-based education, oriented toward democratization and political action taking? How do we know it is happening? What does it look like?

I address these questions from three viewpoints. The first is the knowing that I as a science educator involved in non-formal adult community-based education, have gained through my participation. The second viewpoint pertains to the role of educators associated with schools in the community projects: how have they supported the project and its goals? The third is noting and describing the activities of all the other science

educators associated with the project – how do they learn and educate others through their participation?

Communities are complex learning environments. Researchers in this milieu need to be able to “see” learning as it emerges across relationships, space and time. My observations suggest that through living their daily life, community members produce knowledgeability, which

is routinely in a state of change rather than stasis, in the medium of socially, culturally, and historically ongoing systems of activity, involving people who are related in multiple and heterogeneous ways, whose social location, interests, reasons, and subjective possibilities are different, and who improvise struggles in situated ways with each other over the value of particular definitions of the situation, in both immediate and comprehensive terms (Lave, 1993, p. 17).

In a community setting, there are no standardized evaluation tools or rites of passage from one clearly demarcated grade to another (Lave & Wenger, 1991). Nor are there the controlled conditions necessary to map out series of internal representations or collect response times of a statistical sample. To document the complexity of this knowledgeability, we need a theoretical framework that allows us to notice learning as people go about tasks and interact with others in their own community. This framework should allow us to appreciate the importance of community setting to learning, and it should allow us to situate an individual within the diverse resources and activities found in communities because this is where learning is happening. For this task, an approach to learning broadly called “practice theory” or “situated cognition” is appropriate (Eisenhart & Finkel, 1999, pp. 43-53; Wenger, 1998).

Practice Theory and Learning

Rooted in anthropological and sociological approaches to education, practice theory assumes a “relational” individual (Lave, 1988). Relational individuals derive their identity from their participation within a social context, through the embodied enacting of the tasks associated with that context. Learning and education always occur in the context of cultural activity. Thus, “there is no such thing as ‘learning’ sui generis, but only changing participation in the culturally designed settings of everyday life” (Lave, 1993,

p. 6). In this study, I consider changing participation in activities as learning and the result to be education.

I assume that “learning” is not just limited to ideas, concepts, and skills. Through participation, a practice learned can literally become internalized into an individual’s body (Bourdieu, 1990, chap. 4). I therefore consider the effects of participation on the body, and we study human bodies, their movements and habits, as partial results of learning processes (Foucault, 1977). But this internalization of task and community is also embodied in the more subtle form of how individuals see a situation: what they foreground and background when they walk into a room, what they say in response to challenges, their emotional response to certain events. Maintaining membership within a community of practice has a profound effect on who we are (Wenger, 1998). Thus, the daily habits people enact as they go about their work are central to this analysis. I write about what people do or create in their participation as a template for the analysis of learning.

In this relational model of the individual, the non-human context in which activity takes place becomes important. Society’s values, plans, and control are embedded in the design and presence of objects in our lives (Foucault, 1977; Latour, 1996b). Through such embedding, priorities and concerns become “folded into” the material world (Latour, 1996b; Walkerdine, 1997). For example, the community group I studied installed a fence along the banks of the creek in the local park. This could be seen as both ecological theory and a belief about our obligation to preserve nature “folded into” the material form of a fence, protecting a scientifically defined sensitive riparian zone. In my model of learning, I pay attention to the effects that the material world has on the ability of learners to engage in their activities, how it frames, limits, and enables what they can do and what they can know.

Larger societal structures and institutions also profoundly shape human activity. I am particularly interested in the structuring role of activity with respect to education. By structuring role I mean that what someone learns is inextricably bound up with what they are doing (Chaiklin & Lave, 1993). And what they are doing is always situated within the larger context of society and its structuring institutions. Institutions, through hierarchy, job specialization, and mandates create their own kind of topology (Vaughan, 1999).

Individuals who appear very close in physical space can be positioned very differently within an institution. This positioning is evidenced through differential access to resources, to social capital that comes with job titles, and even through things as personal as speech pattern and grammar (Bourdieu & Wacquant, 1992, pp. 140-152). For example, a secretary and a principal may stand next to each other in the office, but their roles and responsibilities, understanding, and vocabularies used at work are very different.

Finally, I discovered that at the community level, learning was enacted often not within the structures of an institution, but at the confluence of many institutions' influence. "Ecological education" takes account of the complex relations between mediating institutions that constitute the contexts of everyday doing and learning (Cremin, 1976)¹. Thus, "an ecological approach to education, [is] one that views educational institutions and configurations in relation to one another and to the larger society that sustains them and is in turn affected by them" (Cremin, 1976, p. 36). I include this complementary approach to practice theory because it gives a clear voice to some of the meta level issues that became salient as I performed and wrote my research. I adopt this framework of a set of heterogeneous, mutually transforming, and sometimes-nested institutions, each interpreting the other and contributing to an individual's education, which can be understood as an ongoing negotiation of these relations. This is a relevant frame of reference to community-based learning, which involves working within substantial institutional heterogeneity.

Outline

This research is situated within the ongoing activity of people engaged in community-based action with the intent of bringing changed environmental practices to their community. I extend my observations to be general comments on learning that goes on as people engage in community-based action. This paper proposes and answers three questions. The first one is "What are the physical and relational landscapes educators need to navigate as they enter the arena of political action taking?" This question is

¹ The term "ecological" has been appropriated and used to stress a theoretical focus on relationships within systems, and does not connote a concern with biological or sociobiological aspects of community learning.

inseparable from a deep examination of the roles, activities, and relationships in which educators find themselves. To answer this, I note the knowing that I, as a science educator involved in non-formal adult community-based education, have gained through my participation.

The second question I examine is “What does it mean to be a science educator in a ‘community-based education oriented toward democratization?’” If we strive for a participatory non-hegemonic education, we need to ask questions such as: “Who holds the distinction of ‘the educator?’” and “Who is educating whom?” This research suggests that if a science educator is someone whose expertise mediates the learning of others, then there are many science educators in a community group. The third question asks: “How have schools and school teachers supported the project and its goals?” Schools at all levels have important supportive relationships with the community group I have studied.

The remainder of this article follows the following itinerary. First, I present two vignettes, and follow each one with an analysis of some of the predominant features of the learning experience and environment. This is followed by a section where I synthesize some of the themes that emerge from the vignettes and which are consistent with the rest of my experience with the project.

Science Education in the Community

I began this study of science education in the community with an emerging sense that current school science reflects neither what happens in research laboratories nor how science is enacted in the community (McGinn & Roth, 1999; Roth & McGinn, 1997). However, I did not expect the complexity that I actually found, where science and science education is part of, and deeply integrated into, a vast network of activity, (human and non-human) actors, and (political and economic) interests (Lee & Roth, 2001b). In the following, I provide two vignettes from my research, each accompanied by an analysis of how science education, teaching and learning, is enacted in the everyday life of a community.

Breaking the Boundaries- Vignette 1

I was attending the town's summer celebration, "Oceanside Days", as a Project volunteer for our watershed stewardship display. Outside, vendors sold First Nations art, home made jams and mustards, and high school students performed modern dance on the main stage, appearing just after the old timers' Dixieland bands. Inside, the Project shared the display space of the Boy Scout Hall with the Future Community Committee. The Committee was constituted by an informal group of citizens interested in developing a community vision that was based on the desires of the citizens, rather than on random, piecemeal development that was not integrated with environmental and social aspects. They had hosted two workshops in which they had engaged local citizenry in discussions about the future of their community, they had circulated surveys, and based on these consultations, they crafted a coffee-table book, "Livable for All," which presented some of the key features of a sustainable Oceanside. This book contained color photograph collages, line drawing illustrations, and poetry as well as urban planning style commentary.

As we walked in, I noticed a large poster hung on the doorframe, "Scenes from the Pioneer Days." I recognized the style immediately. My friend Tom, an amateur historian with a Ph.D. in ecology had created it. (He is a member of the Future Community Committee and a former Project steering committee member.) There were old photographs of forests of huge Douglas fir sloping down to the Inlet, pictures of roads being hewed like corridors through 150-foot high walls of trees, old homesteads, old taverns. Each was annotated with a caption explaining the contents of the photo and its significance in relation to Oceanside of today.

Along one side of the wall of the Boy Scout Hall the pages of the community resource atlas were posted, a series of over thirty maps of the municipality, each one dealing with a different aspect—aquifers, surficial geology, well locations, optimal grape, and kiwi fruit growing areas. This was the work of another Future Community Committee member, Lorne, a ground water scientist, who had just finished compiling the atlas for the municipality. At another spot, the pages of an illustrated book created by Freda, also a Committee member, were posted. Her line drawings illustrated a creation story from the local Indigenous People.

Stretching along two other walls the pages of “Livable for All” were posted along with illustrations and small reports done by grade 10 students from the local high school. The Future Community Committee had solicited the involvement of a geography teacher and had done a one-day workshop with him and his class. The students and the Committee had a workshop that included discussion about environmental, social, and historical aspects of the community. Using the book as a prompt, each student focused on one part of the book, writing or drawing the results of their work. The Future Community Committee then created a display juxtaposing photocopied pages of their book with the students’ work.

Analysis

This vignette includes several aspects of community education praxis. There are ongoing personal relationships that are tied up in “curriculum,” and disciplinary boundaries that are easily crossed. Education follows an iterative trajectory, as the community cycles knowledge through itself creating a local “culture.” The role of schools (and teachers) has become subsidiary to the ongoing concerns of the community group.

In the community setting, the sharing of factual knowledge is often embedded within relationships between people (Walkerline, 1997). Lorne’s resource atlas was not just a presentation to me, but also told a story of Lorne’s activities over the winter. I had known that Lorne was struggling to complete the resource atlas, so this presentation told me that it had been finished. The resource atlas, as well as being a representation within the context of its subject matter, was also a part of a historical trajectory of the relationship between Lorne and myself. The atlas served as a scaffold for ensuing conversations, where I learned more about both the details of the work he had done and where we shared information about our personal lives. The atlas and the talk it scaffolded served to refresh and strengthen my membership in the extended community of Oceanside.

A striking feature of the presentation was the heterogeneity of the topics covered. Science was not there neatly separated from all other aspects of life. Rather, in this presentation the science was presented alongside with history, anthropology, geology,

ecology, and geography. These are all usually presented as separate subjects, allocated different spaces and times within schools. The Future Community Committee offered different representations of a community all in one space, strands that spoke to the different parts of what a community is. This heterogeneity is something commonly encountered in community education. Thus the practice of community education demands an appreciation for multiple ways of representing a community, where the scientific is but one of many legitimate ways of presenting it.²

The work of the Future Community Committee arose out of their interaction with many people in the community, differently located socially and related in multiple and heterogeneous ways. In that respect, the book is an outgrowth of Committee members' interaction with other community members. The school students are also community members. This presentation, then, articulates one closing of an iterative loop of learning. The Committee learned from the community, produced an inscription, engaged another section of the community, produced more representations and is now engaging the community with the sum of the representations from the first two rounds of engagement. This iterative nature of learning is characteristic of "grass-roots" education as I have experienced it (as opposed to learning curriculum and "moving on to the next subject"), where learning arises from repeated interaction of people within a community around a shared topic of concern. These cycles form the conditions for shared local discourses and artifacts that help create a community's identity (Wenger, 1998).

There were many differently located educators in this scenario, with different subjective and objective possibilities to assist others in learning. Lorne had created the resource atlas from within his area of expertise. Tom, an ecologist, had created a historical representation and therefore worked outside his domain of primary expertise. Freda was telling and illustrating stories from her heritage, which had little to do with her occupation. The book-assignment presentation was the product of a community of educators—people who assist in and scaffold the learning of others—working within and outside their professional domains. These educators also included a schoolteacher and

² In his essay on the settlement of the famous argument between Socrates and Callicles, Latour challenges the motivations behind making science a "foundational" way of perceiving the world, somehow more real than "religion" or "culture" (Latour, 1997).

students. Who was the educator? Who was educated? This scenario shows that there are multiple educators present in community based education, and that an education will be the outcome of the relations between the learner and the network of possible educators (Cremin, 1976).

What was the role of the school in this presentation? Besides providing resources to augment the Committee's book presentation, its participation helped secure funding for the publication of "Livable for All." The Committee had received a \$2000 government grant under the condition that they made their publication "educational." They therefore solicited the support of a local schoolteacher, who had been eager to teach his students more about the geography of the region. The Committee and the teacher arranged a day to present an in-class workshop, where committee members sat as panelists, gave presentations and answered students' questions about the region. In this case, the teacher was seen as a route to a resource, a member of the community that the group would not have otherwise solicited. Now Committee members proudly display the results of the students' work in a public display, which is perceived by the Committee as a gain in social capital. The role of the teacher was not to educate anyone in a direct manner but to facilitate the community group's access to resources. He provided access to students that they could "educate," to money with which to publish their book, and to legitimization of their activities within the community. The outcome—a presentation that includes and is grounded in scientific claims about sustainability—is clearly the result of an ecology of relations between schools, granting agencies, and community groups (Latour, 1999b).

Collecting, Consolidating, and Investigating - Vignette 2

I had come down to the stream to do some routine in-stream restoration work accompanied by Jane, an environmental technology Co-Op student from a local community college on a work term who was finishing her third week as an employee of the Project. Meaghan, the Project's half-time coordinator, was away on her other job.

As I approached the creek, I noticed a trout floating belly-up. I stepped into the creek to pick it up and examine it and I noticed another one, and another, which had collected among the wood and debris along the creek banks. A brown oily film covered the water.

“Jane” I said, “I think we’ll be changing our activities this afternoon. Looks like we’ve got a fish kill”.

It was about 3:30 on a Friday afternoon, and we were unprepared for this situation. I wondered “What should we do? What is important to document?”

I first thought that it was important to walk up the creek, through the rest of the park, and count the dead fish. I needed to do this to confirm that this is indeed a “fish kill” and not just “a few dead trout.” The number was important as an indicator of the magnitude of the phenomenon.

Then, I reasoned that we would have to be able to provide the data that would enable others to determine what had caused the fish kill. What did we need to focus on? What did I have to collect? I knew that we had to find a way to preserve the fish until someone could examine them. We needed to be able to do quick, in-the-field water sample analysis, and that it would be important to take water samples so that lab-based, sophisticated analysis could be performed.

We had none of the equipment necessary. I was not sure what exactly needed to be done or who had the equipment, and we were in a park with no public phone.

We drove to the local pub, where I knew there was a pay phone. We used Jane’s phone list and the phone book to phone John, a fish biologist who worked on a related stream project. I phoned Dudley, the steering committee member who was responsible for water quality testing. I also called Carol, a high-school student, who had also done water quality testing with the group. But we were not very lucky. John did not answer his cell phone. Dudley was on holidays. Carol was home but only for the next twenty minutes before she had to go to work. She was the one who had the dissolved oxygen meter and turbidity meter.

We went to see Carol. She walked us through the sequence of button-pushing actions required to get the proper reading on the oxygen meter, and explained how she used it. She told us what to expect, “it takes a long time to settle down, doesn’t really ever, but after a while I just cut it off.” She demonstrated how to use the field spectrophotometer that is used to measure turbidity, and how to work through the menus, and she showed us the vials that held “test” water and those that held the “blank.”

We thanked her and drove to the Ocean Sciences Research Institute (OSR). It was after five o’clock and the place was deserted. None of their scientists could offer us advice or direct us to proper sample bottles.

We went through shelves but couldn't find anything suitable. Jane led me to an analysis lab where we ended up finding some Erlenmeyer flasks with sintered glass stoppers, which would suffice for our needs. I was thankful Jane knew of this place as I had not known that the Project had access to lab space. While we were at OSR I called John back and was able to reach him this time. He suggested that we take two samples at each site, freeze one, and refrigerate the other. I told him where the kill was and how many fish were there, and he promised to meet us about 45 minutes later.

Back at the fish-kill site, we discovered that the dissolved oxygen was very low. John said that in his twenty years of work in this area he had never seen a reading that low. He was very interested in getting an exact count of how many fish had died and in trying to trace the cause of the kill. There was a scum on top of the water. We wondered whether it was possible to trace it back to its source.

We took John to the point where the creek crosses the major roads in the district and we found the block of farmers' fields within which the transition from clear to polluted water occurred. But we were not able to do too much more exploring, as those farmers did not support the Project and did not want people on their land doing research in their ditches. John gave me the contact number for a provincial agency that could send out a conservation officer, who is mandated to cross private property if he thinks it is important. I would use these numbers tomorrow, and we would find out where this scum is coming from. It was already after seven and the sun was getting low. We would need to find some chest waders to do the proper count John wanted to but there were none at hand at that time. I promised to make the calls to the conservation officer later in the evening, and we would meet up tomorrow morning to do a good job of this fish kill.

Analysis

In the following analysis, I point out the important features of learning in a way that focuses on the situated, social nature of the episode above. This is followed by an analysis of the educators involved as well as the institutional alignments that facilitated science education in this instance.

In this personal account of managing the fish kill, it becomes clear that what is learned emerged from a sustained involvement with a community of practice in an emergent manner and is not well delimited. When I came upon the dead fish and identified them not just as "a few dead fish" but as "a fish kill," the situation—including

fish, affected environment, and the meaning of being a Project volunteer—emerged as a complex phenomenon, setting an expectation for the rest of the afternoon. The activity of the volunteers (including myself) and our learning emerged as we discovered the resources at hand and engaged them. There was no curricular guide informing our actions, there was no checklist of action items, but rather an ongoing participation in a community of practice.

Through my participation that afternoon, I learned science: what it meant to see and represent a “fish kill.” Next, I recount some of the ways in which my participation in the Project enabled me to recognize the dead trout as symptomatic of something else. I had first heard the term “fish kill” two years prior. The fire fighters at the airport had washed out some old gas holding tanks and let the run-off drain into the creek. Forty salmon and trout died. The kill was well publicized in the local newspapers and was an important event at the Project office. Fish kills are also documented in stream restoration and stewardship literature as consequences of pollution discharge, usually as a result of a single discharge into a body of water. Being familiar with the term “fish kill” provided some hunches as to the required information necessary to get the phenomenon recognized as such. My initial activities that afternoon were scaffolded by discourse in which I had previously engaged. They were also supported by my experience as a research scientist, which prepared me for devising a scheme for analyzing the fish kill situation. This historical relationship prepared me to be able to “see” the important parts of the situation, to be able to guess which factors would be important and which were not (Roth, McRobbie, Lucas, & Boutonné, 1997; Walkerdine, 1997). Various strands of a heterogeneous education never previously focused on “fish kill” came together that afternoon at the nexus of the creek and the floating trout within it.

As Jane and I explored the creek and accessed resources within the community, we participated in multiple educative relations. We dealt with a real problem, and improvised a struggle of securing data the extent of which we did not know beforehand. We both learned. By the end of the afternoon, Jane knew about water quality analysis, the people who normally do it, where they live, and how to do some of the water analysis herself. Through my knowledge and relations, Jane’s participation in and relation to the Project and community changed. She was on her way to becoming a functional Project

member not because of a specified curriculum but through her participation in the situated activities of community members. This type of learning is called “legitimate peripheral participation”: newcomers learn what it means to be a community member in all the nuances, both mental and physical, that membership entails through participating in a legitimate activity (Lave & Wenger, 1991, chap. 4).

The knowledge and equipment needed to complete the investigation was literally distributed across the landscape and required a significant amount of coordination to access. In the course of assembling the resources to investigate the fish kill, Jane and I journeyed from the park to the pub, to the grocery store, to the Smiths’ place, to OSR, and back to the park again. We “grazed” the distributed, heterogeneous network of the community to complete our mission. In the course of enacting a scientific investigation and educating ourselves in the process, we find that knowledge of the community, its geography and network of relations, is inseparable from that of the scientific “data.”

The time of day also shaped our action. We would have improvised our struggles in very different ways, interacted with different people, and accessed different resources at a different time of day, or on a different day. For example, had the fish been noticed earlier in the day, we could have gone to the OSR, talked to biologists, and obtained appropriate sample bottles and equipment. Because it was late in the day, at the end of the week, we scrambled to improvise something that would work. Systematic investigation was put off until the following day, hoping the stream conditions would not change. The federal stream stewardship coordinator consulted later that night indicated that the sampling methods were not up to legal standards, and would be useless in defining a polluter, bringing them to court and ensuring change. Science, as a function of the temporal and resource constraints yielded “good enough” results for the group, but they were not good enough for the legal forum.

The knowledge that we gained through and which we needed to complete the community based science action of the fish kill in Henderson Creek emerged as a result of our historically situated activity which took place in numerous locations within a locality and was influenced by temporal constraints. We have found these qualities to be especially prominent in the enacting of community-based science action and education.

There were multiple science educators in this vignette. John, an old-timer in stream ecology, contributed valuable advice about scientific practice as he interacted with Jane and I, the instruments, and the environment. He confirmed our novice use of the oxygen meter and put the low oxygen concentration in context, “the lowest I’ve seen in twenty years of this work.” He suggested a data collection method, that of collecting all observed dead fish, which was far more rigorous than what I had done. By working with John, Jane and I expanded our ability to notice and connect different details of the environment in a way that is likely to give a story that is acceptable to the professional “fish community.” In a situation in which traditional roles were reversed, Carol, the high school student with a working knowledge of instrumentation instructed Jane and I (a former university biochemistry instructor) in the use of the scientific instruments. In this situation, whoever could share their competencies with others became the teacher, free from institutionally imposed roles.

In this scenario, educational institutions and community-led projects are in mutually supportive relationships. I am a science educator who is studying science education at the local university, and Jane is a mature student being trained in technical aspects of environmental resource management at the local community college. Our involvement increases the Project’s ability to achieve its goals, as we are both competent actors in our domains. The educational institutions with which the two are associated also draw benefit from our involvement. The community college benefits by having an opportunity to place Jane, who is a co-op student. This placement fulfills their educational mandate. The university benefits because I can do my dissertation research. Furthermore, the Project’s associations with post-secondary institutions legitimize its standing within the community, and the Project uses these associations in grant proposals to justify further funding requests. My activity (wage) is also supported by a federal granting agency and Jane’s position is funded by a local utility corporation. Our activity as students working in the field fulfills these institutions’ mandates to be more involved in “community projects.” The web of support includes funding agencies, community groups, and post-secondary institutions. Within this configuration of relationships, science education is made possible (Cremin, 1976).

Discussion

Practice theorists work in a tradition that is rich in ways to describe relationality. Relationality is a dialectic where “component elements are created, are brought into being, only in conjunction with one another” (Lave, 1988, p. 146). “Persons-acting-in-settings” rather than the contents of individual minds are the units of analysis. There is duality between participation and representation, an interplay “like the mountain and the river. They shape each other, but have their own shape. ... They cannot be transformed into each other, yet they transform each other” (Wenger, 1998). From this perspective, our own actions are never entirely predictable:

I never act; I am always slightly surprised by what I do. That which acts through me is also surprised by what I do, and by the chance to mutate, to change, to bifurcate, the chance that I and the circumstances surrounding me offer to that which has been invited, recovered, welcomed. (Latour, 1999b, p. 281)

Within this relational framework, I attempt to uncover the important features of relationality that apply to science education in the community. By doing so I hope to provide science educators with a definition of “community-based non-formal adult science education” that accurately reflects the terrain of the community action in which I find myself. I consider six features to be emphasized in community-based non-formal adult education.

1. In my experience, science education does not mean presenting workshops or giving lectures. The knowledge of, felt urgency to address and resources to manage the fish kill were all a result of my participation in the community-based group. The education of individuals arose, in a non-prescriptive way, from participating in the respective activities.

2. The location of learning in community work is broadly distributed geographically. Both vignettes testify to the geographic distribution of resources that the individual actors had to or were accessing as they pursued the activity at hand. In both vignettes, success was related to the ability to identify, define, and access available resources.

3. In community work, an able adult informal learner must learn to master multiple sources of information. There are many texts and styles, one must know how to “read” a landscape, and one must know who is connected to what, and what significance that holds for the project within the community. Traditional institutional boundaries are frequently crossed, as we saw with the Future Community Committee’s presentation, with little regard to professional loyalties, or indeed, in order to create a new representational synthesis.

4. Inter-personal relationships are of vital importance in community-based learning. I find that meaning and information are the outcome of negotiated relations with different individual “gatekeepers” (Callon, 1986). There is no one central authority controlling access to all the relevant information or tools. Because knowledge is often distributed across the community landscape socially as well as spatially, it becomes very important to know who to ask or where to go.

5. Temporal constraints have a large influence in community action learning. Temporal constraints, such as how fast can the operation of an oxygen meter be learned before Carol needed to go to work, are imposed with no regard for how much time might be necessary to finish learning it “properly” or to obtain a “correct” understanding of how the instrument works. Temporal constraints also influenced Lorne’s work on the community atlas. Deadlines are imposed by work schedules, council meetings and departmental guidelines. Expectations of what work to do, and how in-depth it will be need to shift with the time constraints which are imposed (Pickering, 1995, pp. 21-34).

6. Although general, decontextualized knowledge is useful to guide the general form of activity, (for example it was important that I knew the general characteristics of a fish kill), action in a community requires a situated, specific knowledge. In the case of the fish kill, we could not have examined the upstream regions of the stream unless a conservation officer, whose jurisdiction transcends private property concerns, walked it. Scientific knowledge was dependent on the configuration of relations between the physical (the landscape and drainage ditches), and legal (private property rights, suspicious landowners) institutions, as expressed in a community. This configuration, through the participation of John (who had situation specific knowledge about environmental protection in the province), led us to seek another actor to complete our

scientific task, in this case a conservation officer whose jurisdiction included private property. Thus through the use of our situated knowledge, we were able to orchestrate the many relations in the community in such a way as to enable the completion of the investigation of the fish kill.

These are six features of learning within the ecology of community-based action taking. By considering science education at the community level to include these features of activity, I expand the definition of informal adult based learning in the science education context.

In both vignettes, we find people with expertise in science practice mediating others' understanding of science, whether it be through the creation of publicly posted geological maps, or helping me with the technical aspects of water quality measurements or ecological data collection. In these cases, a science educator is someone who helps another person learn how to do scientific work within the Project's goal trajectory. During the fish kill situation, I educated and was educated by John, Jane, and Carol, each contributing to a different aspect of the "creation" of a situation. A learner must know whom to ask about what. Different educators provide different kinds of advice and contribute to different types of activity. Also, the distinction between "teacher" and "student" becomes blurred. "Teachers" become students and "students" become teachers, as in the case of Carol instructing me in the use of chemical analysis equipment. In the community, education is a "patchwork," a collection of specific suggestions or actions that pertain, are relevant to and are located within local events.

The role that science educators who teach in schools find themselves in is a profoundly different one than the one that they face in the classroom. In our case study, school participation is seen as:

1. Another way of legitimizing the Project within the community
2. A potential source of simple data that is useful in their political work
3. A public service (e.g. when teachers ask the Project to participate in Earth Day activities)
4. A way to increase their "reach" into the community through parents attending Project events that they might otherwise not attend
5. A fulfillment of obligations that granting councils have imposed on them

In these instances science teachers did not take center stages as teachers of students; they did not take center stage in educating the adults involved in the Project. Rather, science educators became educated through their participation with the project. In return, they helped the Project build legitimization in the community, gain access to granting agency money, and speak their message to a broader audience, perhaps interesting people who had not heard about the Project and its activities. Science teachers and schools have been great supporters of the adult informal education in that regard.

At the institutional level, science education in the community is the result of the configuration of multiple agencies. In the case of the Project, the federal research institute, three post-secondary institutions, a major local crown corporation, the municipality and regional and provincial agencies all contributed resources that resulted in the activity of science education. What may seem like a simple undertaking is really the instantiation of a delicate balance of many types of relationships.

Conclusions

I can now frame the participation of science educators involved in community action in a new light. First and foremost, in community-based political action taking, learners and educators must navigate a set of configurations or (spatial, social, and temporal) relations that are more varied and complex than that experienced within the school. Curriculum is often improvised on the spot, in response to situations that arise and require immediate attention, and is a function of these sets of relations. Individuals must be able to cope with finding access to and interpreting multiple texts, each speaking with a different kind of authority, based on the concerns and expertise of the communities that produce them. Individuals must know how, when, and for whom to deploy these texts or representations in their presentations. Again, they need to navigate a course of action through a varied landscape. The boundaries between “educator” and “learner” are especially fuzzy, often shared between people who are participating in an activity. Depending on what is done, the role of educator switches between persons, as a function of differential expertise and experience of those present. Finally, in this landscape of roles, institutions, geographical distribution and relations, individuals with an institutionally granted title of “science educator” often find themselves in a non-

traditional role. They are not teachers, evaluators, or motivators but simply cooperating participants. Their interests may well be subservient to those of the group.

How can science educators support non-formal and non-academic adult and community-based education oriented toward democratization and political action taking? My research suggests that they need to be keenly aware of the different ecological education landscape of community-based political action. They also need to discover the multiple educators and authorities available and they need to realize the relevance and importance schools may have to the needs of the groups. All this may have little to do with “educating” as it is ordinarily conceptualized.

Chapter 9: Science and the “Good Citizen”: Community Based Scientific Literacy

This chapter was written in the late summer and fall of 2000 about an event that occurred in the spring of 1999. It was written for an audience of STS scholars and has been submitted for publication to the journal “Science, Technology and Human Values,” the publication of the Society for the Social Studies of Science (4S). It was first presented as a talk at the 4S meeting in Vienna, Austria in September of 2000.

The chapter is formulated to loosely address the organizing question of that conference: “The greatest challenge to studies of science, technology and society at the end of the second millennium is to understand how science and technology are implicated in the processes of change and transformation that are massively reshaping our world.”

I answered that challenge by illustrating how one grassroots activist group attempts to change the way their community sees and interacts with its landscape, particularly the creek. I detail the work they do to make their scientifically based discourse relevant to the public and to associate their science with moral arguments.

This chapter uses a theoretical base similar to the one developed in the previous chapter, “Remapping the Landscape,” focusing on how people come to know within their immediate everyday surroundings (Lave, 1988). Here, the analytic notion of active meaning making, in distinction to the usual way of ascribing meaning to certain signs is developed. This approach focuses on how a representation or object participates in the meaning-making activities of the individuals with whom it is co-present. This type of semiotic analysis is called social or ecosocial semiotics (Lemke, 1995). This chapter uses an ecosocial semiotic framework in an attempt to theoretically articulate knowing-in-situation. Textual analysis is also employed to show the frequent occurrence of certain thematic pattern in the activists’ talk and writing.

In February 1999, the Henderson Creek Project received \$5,000 toward a stewardship program. They decided to hire a coordinator and put on an Open House to which MLA’s, radio stations and many local dignitaries would be invited. The coordinator, a steering committee member, spent three months bringing together a network of other stream restoration groups, educators and local citizens to host this one

day event. I participated as the organizer's assistant. I thought that being a key part of their educational campaign would be an important aspect of my research into teaching and learning in the community.

The paper is based on data I collected while I helped to organize this event. I have extensive field notes from my participation, key letters and internal planning documents, videotape and photographs of the day of the event.

Thematic Issues

The central problem of this paper was framed in terms of scientific literacy and its relation to "positive" social change. Thus, once again, scientific literacy is articulated in terms that are amenable to the argument I put forward. In this case, quotes from the American Association for the Advancement of Science (AAAS) are used as a point of contrast. The hope of the AAAS, that a good science education would provide students with understandings and "habits of mind" that allow them to become "compassionate human beings," participating in a society that was "open, decent and vital," was critiqued along three lines. The first, by now familiar, was to problematize the notion of "habit of mind." The second was to challenge the argument that punishing, authoritative science education (taken as standard practice) would help students learn the practices of good citizenship. The final point was that many current scientists are engaged in practices that could be hardly considered conducive to an ideal society. Scientific literacy was then re-framed in terms of effective scientific doings that were community based, politically positioned, and morally legitimized.

From this re-framing the analysis was developed. More than the other two chapters on scientific literacy, this one examines it within the context of active, morally laudable citizenship. A coherent argument is made for what I see as scientific literacy at this site, its relation to community, and as well as to science's moral place in society.

Following the work begun in the previous paper, relationships and representations are treated as closely intertwined. The narrative focuses on the plethora of both that develop in and through the activity at the open house. The social nature of representations, the representational aspect of relationships, the relationships that arise through activity are all extensively treated.

This paper develops the notion of heterogeneous representations and concomitant activities and relationships to its end point in this dissertation. Heterogeneous ways of representing the creek, coexisting in one space, for a day, is related to the diversity of relationships, scientific literacy and an ideal society where many meanings can coexist together.

Science and the “Good Citizen”: Community Based Scientific Literacy

Introduction

This is a paper about science’s involvement with values.¹ A particular kind of values—those associated with “good citizenship.” It is about how, in an effort to introduce scientifically informed values into a municipality, a community-based group works to insinuate scientific discourse into other community discourses, enlisting as many community members as possible. This paper is also about education, and what an education that achieves the dream of science reformers who work toward a literacy that supports “an open decent and vital” society, might be. I ask “How may ‘good citizenship’ values arise and come to be expressed in a community?” I propose a complex response to this question, and attempt to embrace this complexity rather than to oversimplify it, while nonetheless making my arguments intelligible.

How can science and learning science benefit society? Science literacy advocates, both those arguing for higher standards and more scientific curriculum (AAAS, 1989) as well as those who take a more critical approach (Eisenstein, 1996; Fourez, 1997; Popli, 1999; Roth, 1998), often claim that a better science education will enable a person to be a better citizen. The question, “What would a citizen-empowering science education look like?,” is pursued here as part of an ethnographic research project into the use of science by a grass-roots environmental organization. I noticed that as part of their educational program, they work to include environmental concerns in moral and ethical discourse. Science was included in value talk and linked to “good citizenship.”

¹ What do I consider to be “values”? I consider “values” to be a discursive construct by those who are talking about them. They are useful for us as the word helps us talk about our opinion about the intent and goodness of a certain activity. It also enables us to make opinionated meta-statements that allow us to construct a model based on the sum or relationship of a number of interactions or events that we notice and evaluate. I certainly do not reify values, or believe that they “underlie” actions. They are part of our conversation about our judgements and opinions about our experience. These discursive practices, are of course, not unrelated to other actions in the world, and may well be associated quite closely with actions through felt experience.

In this article, I highlight the environmental activists' efforts to introduce scientific discourse about local streams into that of the community by analyzing an open-house event that they organized to begin a stewardship campaign. I focus on the material, social, and representational (discursive) formations they use to make scientifically informed values salient to peoples' experiences in and of the community, and as the activists hope, to these peoples' everyday practices. I chose this open-house event as a way of illustrating my argument because it was a site where many of the usually dispersed activities and relationships of the activist group were enacted at a singular site and a single point in time. Science was part of a discourse that included ethical and moral concerns about community well being. Thus, an account of the open-house event is an appropriate place to pose the question, "How does, and how can science contribute to a better world?"

I argue that science literacy, to achieve its goals of good citizenship, needs to be embedded in other mediating practices. Three types or sites of such mediating practices emerge from our case study: social-material meaning making through site selection and spatial-material arrangements, the importance of heterogeneous relationships and the different discourses that accompany them, and embedding scientific discourse in moral talk. These three points become resources for reframing scientific literacy.

Reframing Scientific Literacy

Scientific literacy is often described as a pre-requisite for a person's empowered, full citizenship. In its publication "Science for all Americans," the American Association for the Advancement of Science suggests that "science education... should help students to develop the understandings and habits of mind they need to become compassionate human beings... [and] equip them also to participate thoughtfully with fellow citizens in building and protecting a society that is open, decent, and vital" (AAAS 1989, p. 1). This quote explicitly describes a direct link between science literacy and the formation of a good citizen. The rest of the AAAS text describes strategies for improving science education in schools as a way of achieving this result. This science education is based on helping students learn the "habits of mind" that practicing scientists supposedly possess (Roth and McGinn, 1998). What is missing from the document is the description of a set

of mediating practices that place science and science learning² in situations where “good citizenship practices” are performed.

In terms of helping to foster the development of good citizens, I see a number of problems with the approach based on students’ ability to imitate scientists’ discursive repertoire within the classroom context. The first problem, well articulated in science studies, is that “habits of mind” cannot be considered as isolated from the material and social practices of those demonstrating these “habits” (Amann and Knorr-Cetina, 1990; Law, 1987; Pickering, 1995). Thus, students who sit in classrooms, copy notes and engage in token hands-on activities are unlikely to acquire scientific “habits of mind” because they do not have access to tools, social situations and practices that mediate the activities of scientists. In this study, I provide a description of learning that is different than that of “habits of mind,” focusing rather on the key points of social-material relations, activity and authenticity (Chaiklin & Lave, 1993; Lave & Wenger, 1991). I describe how the activists use physical space as a frame for integrating science into other community narratives, to direct the movement of people in such a way as to direct their experience of the creek (see the section “A Bucolic Location” below). People worked with models, talk about alternative resource uses, different cultural significance, about the creek’s changing identity over and with appropriate inscriptions and tools. They participated in an authentic event, one that has consequences and relevance to their neighborhood, and discussed issues with actors who work on the issues in fora where decisions are made about the creek. Thus participants engaged with a variety of social material resources, in a context of activity whose outcome is meaningful to the subject of their talk.³

Second, the tension between the stated goal of active citizenship and the reality of science education in everyday classrooms makes the reform rhetoric problematic. In general, the current practice of science education focuses on the students’ conformity to

² I use the term “learning science” here to distinguish it from that of a “science education.” The distinction is that learning science happens as one engages in scientific practice, wherever that may be, while “science education” implies a curriculum-driven course of instruction, whether done within an institution or based on an activist’s specific agenda.

³ As opposed to in-school discussions, where the outcome of the discussion rarely impinges on the object (for example, the health of the creek) being discussed, but rather contributes to the evaluation of the discussants’ performance.

authoritative knowledge and scientific discourse that is relevant to research scientists, whether it is “discovery learning” or traditional lecture-style learning (Roth, 1998). Generally, students are taught one way of representing “nature” and are graded on their ability to mimic what they are taught. Alternative meanings, espoused by the humanities or marginal cultural groups are generally ignored and sometimes mocked. This type of activity encourages participants to consider “scientific” issues from one perspective and seek approval of a legitimated authority to validate their actions rather than participating in critical and democratic discourse (Roth and McGinn, 1998). Evaluating students through traditional testing procedures is a practice that creates isolated individuals, unable to rely on others for help in articulating and solving a problem. In contrast, the environmental group in our study seeks to make themselves as relevant and legitimate as possible to as many people as possible. The open-house event that they perform enacts multiple mediations and translations of scientific topics into those related to everyday community life (see the section “A Dispersed Community in One Location” below) (Callon, 1986). They offer new and alternative versions of typical community discourses, posing new relations. They question previous authoritarian representations (Lee & Roth 2001b), even typical science itself. It is from this nexus of questions that productive community-based change emerges. Through their participation in the open-house event, visitors enact both learning and teaching as they enter into relationship with the hosts. The resulting science includes referents situated in the community. Unlike traditional science teaching, this site provides multiple perspectives, includes other cultural models and emphasizes relationships in the practice of scientifically informed citizenship.

Third, in the past science education curriculum was articulated as if the goal was to turn all students into “little scientists” (McLaren & Barton, in press; McGinn & Roth, 1999). Cognitive-apprenticeship models went further in this endeavor proposing to enculturate students into the practices of laboratory science (Brown, Collins & Duguid, 1989). I question those who envision science education as an unreflective and uncritical enculturation into scientists’ science. There is nothing inherently moral about the practice of science (Beck, 1992). The language games associated with “objectivity,” “scientific neutrality,” and “impartiality” discourage talk about the political and social aspects of science. This silence in fact allows scientists to retain their morally neutral, “above

politics” position while they serve corporate interests opposed to democratic governments, develop instruments of mass destruction, and argue passionately for policies that could well be considered eugenic (Noble, 1992).

My case study, however, describes a group that puts in long volunteer hours to make their community a healthier place for the future, not just for themselves.⁴ They practice inclusive politics, argue for and dedicate resources to aesthetics, and volunteer their time in schools. They also explicitly deal with moral issues. Discussion about what is right and what is wrong to do come up in their everyday talk, in interviews and in the material they distribute (see the section “Stewardship Triad” below). Through partnerships and funding agreements, these activists are also directly involved with provincial, federal and municipal governments, and can be considered to be advancing these organizations’ environmental restoration mandates. Unlike the practitioners of science who claim to be working out the properties of a rationally understandable world “to protect ourselves from the irrational tendencies that still beset humanity” (Weinberg, 1996), the activists make no claims of objectivity. They are engaged in a passionate practice that is fundamentally politically positioned.

In this case study I describe a science and a type of science education that is community-based, politically positioned, and morally legitimized. I argue that it is an excellent instantiation of what science can be when used in fora that engage participants as citizens.⁵

The argument begins by introducing the environmental activist group and by situating them within their community. Then analyses of a different aspects of a one-day educational open house event organized by the activists are presented. This paper is completed by reconsidering the notion of scientific literacy and by reflecting on the relationship between education, science, and citizenship.

⁴ Their mission statement makes it clear that they are working for both human and non-human beings in the watershed, both those who are living now and those who will come in the future.

⁵ By saying this, I am in agreement with Eisenhart (1996), who also argued for and presented case studies outlining the benefits of community-based ecological restoration practice as a legitimate way of learning science.

The Municipality of Oceanside, the Henderson Creek Project

The community of Oceanside sits on a peninsula in North America's Pacific Northwest, which is bordered on one side by open ocean and on the other by Sandwich Inlet. The peninsula is part of a region initially inhabited by indigenous peoples and subsequently has been taken over by people of European ancestry about 135 years ago. Since that first contact, many of the marine species in Sandwich Inlet that have provided the staple for the First Peoples have disappeared, or exist in drastically reduced numbers (Sandwich Inlet Study 1996). Although some of these declines can be attributed to over-harvesting, the exact cause of much of the disappearance remains unexplained. Land use has been strongly implicated. The peninsula has been farmed for more than 100 years, drained by a ditch system that has replaced many of the local creeks. Industrial developments also discharge pollutants into the ditches. With increasing population and development, storm drains, too, become part of the ditch/creek system. Thus the inlet receives agricultural, septic, industrial and road waste through the waterways that drain into it. Both governmental (CRD 1998) and local action is being taken to address the problems with this scenario.

In 1997 the Henderson Creek Watershed Project ("the Project") was brought to life by a small number of local residents who were able to secure funding to hire a coordinator. The Project seeks to "protect and enhance the Henderson Creek stream system" (Henderson Creek Project [HCP] 1998, 23) to provide sufficient water for both the ecological and human needs of the watershed. At this time, the Project has a paid coordinator, Meaghan MacDonald, who generates and coordinates the group's activities. However, the goal of the Project is to become so integrated into the community that this position is no longer necessary. Meaghan stated, "What we want to see happen is that the community embraces the concept of a healthy watershed and takes it on themselves" (undated newspaper clipping). The mechanism through which the Project hopes to accomplish this is its stewardship campaign.

Through its stewardship program, the Project seeks to educate landowners in watershed stewardship techniques because "every watershed resident influences the health of Henderson Creek" (Henderson Creek Project [HCP], 1999). The stewardship

package includes brochures on a variety of issues. These brochures provide information on how to disconnect a downspout from the storm sewer system, how to put more water back into the ground, how to plant with native plants (thereby reducing dependence on fertilizers, pesticides and herbicides), and how to pave with concrete bricks containing large holes that let rainwater through (HCP, 1999, May 24). Its goal is to make stewardship compelling yet attractive and fun so that more community members participate and help to reverse the environmentally destructive trend that was set in motion by the European settlers as soon as they arrived. The open-house event, which was considered to be the beginning of an aggressive stewardship campaign, is an excellent site for making sense of how the activists attempted to engage local citizens in scientifically informed practices, because that was their explicit goal in putting on the event.

The open-house event (the “Open House”) analyzed below was meant as a “kickoff” to the stewardship campaign. This event was a major thrust of the activists’ activity and took about three months to plan and enact. The Project applied for and received a \$5,000 grant from a provincial government agency to hire a coordinator and to cover the expenses of putting it on. Thus I am confident that I am analyzing an event that is the result of substantial planning and thought by the activists in order to provide an occasion for community members to engage in scientifically informed moral discourse about the creek.

The following analyses describe the situated activities of participants. I describe interactions with people (Who are visitors talking to? What registers/genres do they use?) and materials (What inscriptions and artifacts are they using?), and contexts (How do visitors activities relate to the setting?). A social material semiotic approach to meaning making is especially useful in this theoretical context because it highlights how people *enact* meanings in social settings rather than passively “acquiring information” (Goodwin, 1995; Lave, 1993; Lemke, 1994). Thus learning is equivalent to people’s “changing participation in the culturally designed settings of everyday life” (Lave, 1993, 6). This type of analysis has a long history in STS, where the structured and structuring role of the environment on people’s activities has been eloquently articulated (Amman and Knorr-Cetina, 1988; Latour, 1996b; Law & Mol, 1995; Lynch, 1994). It is also a

preoccupation of scholars interested in “situated cognition,” a notion that takes learning per se as a more central analytical focus (Hutchins, 1993; Lave, 1988, 1993; Lave & Wenger, 1991). In this article, it provides the intellectual framework necessary to articulate the changes and transformations and activities described in this informal setting, free from standardized “evaluation instruments.”

Social Material Engagement of Participants in Scientifically Informed Meaning Making

The overall purpose of the Open House was to engage the public in talk and activities about Henderson Creek, with the intent of interesting them in the stewardship program. This event was designed to bring science (in this case stream ecology and hydrology) into everyday life. My overarching interest in this paper is to articulate features of community level science enacted by the activists that I believe can contribute to better citizenship. I am therefore sensitive to both activities I see as “learning science” and to those that would contribute to “good citizenship.” Thus I focus on the activists’ efforts to make science and creek talk relevant to and become a part of people’s everyday lives.

In the following sections, three major features are analyzed that seem to be sites where individuals can participate in novel ways in relation to the creek and the activists. I frame these sites as events, or occasions to enact new meanings. I begin with an analysis of how the choice of location and the spatial arrangements therein shaped peoples’ activities, introduced them to new discourses, and created associations between ones that had not been previously associated (“A Bucolic Location”). Next, I bring out some relations that emerged from the activity structured by representations brought to the Open House by members of different communities of practice (“A Dispersed Community in One Location”). Finally, I analyze a typical discursive thematic pattern employed by the Project members to invite community members in talk about stewardship of the creek (“Stewardship Triad”). These analyses emphasize the variety of meanings structured around scientific discourse and activity that proliferate in an event like an open house.

A Bucolic Location

Many scholars have critiqued the models of mentalist cognitive science typified by the phrase “habits of mind.” Instead they put greater focus on how material arrangements frame meaning-making social relations (Bourdieu, 1990; Latour, 1996b; Lave, 1988). That is, space is an important semiotic resource (Brown & Duguid, 1996; Goodwin, 1995; Hodge & Kress, 1988). In its organization of the Open House, the Project used space and physical structures to contribute to other parts of meaning making being enacted. I note four instances. First, the choice of setting allowed the Project to situate itself within major historical narratives of the community. Second, the landscape was used as a resource to shape people’s experience. Third, inside the presentation hall, the setting mimicked an academic poster session, and finally, the proximity of the creek to the location of the Open House allowed the scientific representations of the creek to be directly juxtaposed to people’s embodied experience of the creek. Thus space and the arrangement of objects were chosen to deliberately introduce connections and forge discursive-experiential links, weaving the experience of the Open House tightly into other aspects of the everyday life of community members.

The Project decided to locate the Open House in the hall and grounds of St. Michael’s church. As this public service announcement indicates, the particular location was more than just space that they filled up with their displays; it associated the project’s work with a major theme in the community—its heritage.

The choice of St. Michael’s church as a venue for this event extends beyond its bucolic location. Henderson Creek flows through a valley originally graced by open prairie and garry oak meadows maintained by the Wseseynish people living at Tsarcum: the beauty of the area also attracted the first European settlers to the Sandwich Peninsula in 1855. (HCP, 1999, April 9)

In this public service announcement, the Project makes reference to three strands of the region’s history: its natural, First Nations and pioneer history. This small community of 12,000 takes great interest and pride in history: it maintains two museums dedicated to local history and is currently engaged in a campaign to raise the funds for a third. This pride is not limited to the pioneer descendants. The First-Nations community

has published numerous historical books that are used in local schools. St. Michael's church, the site of the Open House, was one of the first structures built in the community and is the oldest still functioning church on its original site in the province. The Project made this historical link explicit by hiring the local historian to spend the afternoon in the church's graveyard, telling stories of the pioneers buried there. They also reproduced the first map ever made of the region, and illustrated it with colors and icons representing the different landscape features written in the surveyor's diary. Thus the creek became part of the historical narratives of the community. The activists constructed it historically through narrative, and used the choice of the site to embody and reinforce this construction. The site acted as a sign, a participant in a larger discourse.

Meaning was also woven into the landscape itself on a physical scale:

The Open House site was nestled in the lower portions of the Mount Newcombe Valley, with Henderson Creek running only hundreds of yards away. The farmer whose fields were adjacent to the church had mowed a pathway to the creek through his hay field. Signs were made, encouraging visitors to walk down and along the creek. [Field note]

In this instance, the landscape itself is formed into a sign system. A pathway has been cut through the fields of hay, and signs lead visitors down to the creek, where interpretive signs inform them where they can go and what they can see. The activists have carved meaning into the valley, changing a landscape into a directed, purposeful walk. The swathe through the hay, and the signs all indicate that people are free and encouraged to walk through what is otherwise private property. Thus, private property rights are temporarily suspended, and people are guided to experience the creek as it flows through the valley.⁹ Through the activity of walking down to the creek, people obtain a first-hand, embodied experience of it. This experience, situated in the familiar Newcombe Valley, is a new way of engaging the landscape for most people.

The Project, the middle-school students, and other stewardship groups posted their displays inside the church hall on tabletops arranged around the periphery of the room. Many of the posters dealt with scientific topics, such as "how a stream works."

⁹ Henderson Creek flows entirely through private property as it travels through the valley on the way to the ocean, so this is a rare opportunity for visitors to observe the creek closely.

“ecosystem features of the Sandwich Inlet,” or the contribution of chicken farms to fecal coliform⁷ loading in the stream. The space and its contents strongly resembled an academic poster session. The physical experience of those moving about in this environment and engaging in discourse while pointing to and talking about various representations of the landscape fit with experiences had while in the legitimized environments of a trade show, a municipal public-information session, or an academic conference. Thus, again, the use of space supported the type of meaning making that was going on within them. The activists’ new information was presented within familiar, legitimate bounds.

The scientific representations were situated within the physical environment of the creek that they purported to be representing. This pairing of science and naturalistic frame brought an aspect of reflexivity to these representations, as they were paper-based inscriptions about a landscape within which the paper inscriptions were embedded. Many visitors, after reading about Henderson Creek in the activists’ displays, walked down to the creek to “see for themselves.” The science posters were therefore reflexively embedded within the physical landscape that they represented. This created an opportunity for people to make the connection between their embodied experience of the natural world and the artifacts and representations that were produced by the activists. Thus, through the construction of a spatial arrangement, the activists supported the purpose of this part of the event, which was to present the community with opportunities to engage with the creek.

Here, the activists employed space as a semiotic resource to frame the event (Brown & Duguid, 1996), understanding that a landscape can participate in meaning making by framing and channeling people’s movements and discourse in very specific ways. They used a number of “prompts” to frame the talk and motion, including making pathways, assigning knowledgeable people at strategic locations and placing their representations within a special kind of built environment. The actual object of their inquiry was present at hand, and represented as a historically constructed discourse, linking embodied with discursive experience (Latour, 1996b).

⁷ Fecal coliform are bacteria that are taken to be indicative of sewage contamination of a watercourse.

A Dispersed Community in One Location

As opposed to the “ivory tower” image that many people use to portray institutional science, the Project is part of a heterogeneous, dispersed, multiply marginal⁸ community of practice. It depends on good relations with homeowners, schoolteachers, scientists, university co-op coordinators, bureaucrats and others to get its work done. In one sense, could be defined as the living sum of these relations. The Open House was an opportunity for many of the contributing organizations and individuals to be present at the same time and in the same space. Many groups brought displays or set up activities. There were displays on the history of the watershed, watershed ecology, and stewardship activities by the Project; displays by middle- and secondary-school students; displays from other watershed groups on the peninsula; First-Nations art, featuring the Project’s logo-in-progress; information from conservation organizations and local nurseries; representatives from the federal government; presentation of stewardship certificates to the first group of stewards by the mayor of Oceanside (HCP 1999, May 17).

In this section I explore ways in which the differing participants contributed to the meaning-making activities. I highlight some of the different types of representations present, and the different types of activities in which they are embedded and to which they contribute. I also foreground the relational aspect of this learning landscape, something that is often downplayed in literature on science education. Relationships at the community level are not only important in terms of access to people with information, but they also work to position an organization within a community, which in itself is an important act of meaning making. Finally, I note that in situations like these, learning is not a one-way transmission of knowledge from expert to novice but an exchange in which often both participants are educated about the creek in the community.

The presence of different presenters, with different backgrounds and from different professions—therefore representing different communities of (discursive) practice—offered different opportunities for meaning making. Because of differences in occupations and interests, these presenters brought a variety of discursive repertoires to

⁸ Here I mean “multiply marginal” in the sense that Star developed the concept, which implies belonging, peripherally to multiple communities. I do not use it to indicate that the Project is disempowered or marginalized over and over again. See Star, 1991.

the Open House. They also brought different types of representations of the creek, coordinating different kinds of activity. Some brought posters, which people gestured and spoke in relation to. Others, watershed models, in which people were led stepwise through a series of actions to a simulated outcome, a rainstorm falling on the watershed. Still others brought microscopes and helped people interact with creatures that had been removed from the creek. In the following field note excerpts, I describe some of the different sites of interaction.

Multiple sites for making meaning

1. The First Nations carver, a nationally recognized artist, whom the Project had hired to design the logo for their stewardship program, chatted amiably with passers-by. On a card table, he displayed the logo-in-progress along with some of his other recent work. When completed, the logo would be affixed to lawn plaques that stewards would be able to display.

Visitors who talked to the carver likely entered into discussion about the animals that once lived in the valley, the landscape features pre-settlement, the place the Creek had in their spiritual lives, and the effect of treaties on his Nation's lifestyle. His representation of Henderson Creek, a logo commissioned by the Project, represented the animal life in artistic form and included geographic features that were of significance to his people. The carver often pointed at the representation and talked about the ways, for instance, in which his people use the small island just off the mouth of the creek. He provided visitors with opportunities to understand the creek, elsewhere in the Open House represented by dissolved-oxygen levels and coliform counts, in terms of its connections to a different culture and way of life. In his person, there existed a resource to link science to history and First-Nations culture.

2. Late in the morning, all the visitors were called to a central location. The mayor of Oceanside presented a speech in which he praised the efforts of the Project and those who had taken up the important task of being stewards. Stewardship certificates were awarded to the dozen stewards.

The mayor's presentation was a symbolic act that had the potential to strengthen to position of the Project in the community because he spoke as the mayor at a public event and thereby represented the council and municipal government. In the speech, the mayor combined aspects of scientific and political discourse, putting each into new relations and thereby transformed them. For example, he brought together "watershed" and "healthy ecosystem" with his government and its stated policies and thereby provided a link between institutions and environmental features that had not existed before. Through his participation, the Project demonstrated that they were considered a legitimate organization by the elected local government.

3. Karen, the water technician hired by the Project and a supporting farmer to monitor water levels in both the creek and the water table, led children in the construction of "groundwater aquifers" in upside down two-liter pop bottles with their bottoms cut off. The children had a choice of materials from which to construct aquifer—sandy, clay-type or organic soil and also could put "impervious surfaces"⁹ on top of the aquifer. Once they had made their soil cocktail, Karen poured water onto it and the children could see the water's path through the container's clear walls. As the children built and watched their experiments, Karen commented that these pop bottles mimicked different types of soil strata in the municipality and the flow of ground water through them.

The water technician Karen engaged the children in a classic scientific practice by setting conditions to help them make models of "natural phenomena." Her discourse structured the event so that the talk moved between the properties of the materials they used and those of the materials represented. These elaborations therefore provided opportunities to better understand groundwater flow. Karen provided an opportunity for children and other visitors to experience "hands-on" pedagogy, which led the learner through an exercise, forming relationships between what they did with their hands and what was going on underneath the ground of their community. In this situation, though, there was no right or wrong, the participants made their "aquifers," did the experiment of

⁹-Impervious surfaces' such as roofs, parking lots and roads have a major impact on streams as they keep water out of the ground, and contribute through their connection to storm drains to flash floods of dirt and petrochemical-laden water during 'storm events'. A 12% coverage with impervious surfaces is enough to impact a salmon stream, and 18% is correlated with over 90% loss of salmon.

pouring water on them and got results, which Karen then related to soil type and ground water flow.

4. Two Project members had spent the early morning collecting small animals from the creek and stored them in an aquarium in the shade of a weeping willow tree. Trout, stickleback, newts and a crawfish were present in the aquarium, evidence that what some called a “muddy ditch” was indeed a living thing. The Project members placed dissection microscopes next to the aquarium, along with ice-cube containers holding some of the small invertebrates that lived in the creek. Visitors could examine these creatures through the microscopes and discuss them and their significance with the attending committee member.

People visiting the aquarium had an opportunity to see the creatures that lived in the creek. Since many people in Oceanside do not know Henderson Creek exists,¹⁰ showing them that there are different species of fish and invertebrates in the creek is important. The aquarium is also a representation of the creek, presenting a stylized, concentrated view of the creatures that live in it. The Project members stationed at the aquarium were eager to tell visitors the locations where the animals had been found, and to work with them at the dissecting microscopes, handling viewing, and talking about the creatures which they were examining.

In our four episodes, we see the creek/watershed represented in discourse, visual art, muddy models, and fish swimming in an aquarium. These representations did not stand alone, but functioned in the coordination of activity through which meaning was made (Amann & Knorr-Cetina 1990; Lynch 1994). In the four episodes listed above, people participated in discourse about the importance of the environment in civil politics, engaged with microscopes and specimens, identified fish species, packed bottles with dirt and poured water on them, and other activities. There was variety in the representations, resulting in different opportunities for participating. Other representations present at the Open House included a display of native plants by the local native plant nursery, a video featuring artful shots of the creek, set to music and played continuously, aerial, cadastral

¹⁰ In fact, I noted early on that these activists, like those who focused on other creeks in the area, put up signs marking the creeks where the roads cross them, thereby making the creek “re-markable” to the community.

(maps used for planning, showing property lines and streets) and historical maps of the area, microbial counts, and a trivia game designed by middle-school students.

The creek is re-presented in multiple discourses, artifacts, gestures and activities. For each Open House participant, an identification of a creek invertebrate and construction of an “aquifer” provided a resource for change, that is, learning about some aspect of the Henderson Creek and the watershed it empties. Creek science as it is enacted in this open-house setting includes many of the elements that vascularize science into society: historical narratives, economic interests, environmental and governance concerns (Latour, 1999b, chap. 3). This variety of meaning making events available to the Open House participants stands in contrast to the usual monologic¹¹ discourse that predominates textbook approaches to science. Science, in the case of the Open House, explicitly supports the values of inclusion and valuing heterogeneity that (in our view) are crucial to good citizenship.

At this stage it is important to acknowledge that, for example, the disciplines of history and stream science are different and for the most part separate. Nonetheless, at the site of confluence of practice that a grass-roots situation presents, multiple disciplines are brought to bear on solving problems¹² (Fourez, 1996, 1997). To continue with our example, both history and ecology must be co-present and engaged to bring about the restoration of a creek. Events such as the Open House are valuable as a way of learning about this multidisciplinary practice of science in the community, through engaging in multiple activities organized around a variety of representations of the creek.

Just as much as attendees become exposed to the various concerns and representations of the creek in their community, they, as residents, brought their own knowledge about the creek and its place in their lives to relations with Project members. In the transcript excerpt below, recorded at an earlier open house the Project had hosted.

¹¹ This is a word used by Mikhail Bakhtin to indicate a unitary, dominant view of representing the world (Bakhtin 1981, p. 61). In the case of most school science, we are trained to accept very narrow ways of representing the creek rather than multiple implications, stories, and ways to move the activists involve us in.

¹² As part of his work on the practice based description of science doing in everyday life, Fourez claims the ability to create and navigate ‘rationality islands’, groups of practitioners from disparate disciplines who congregate to solve a certain problem as an issue of central importance.

we see Walter, a school principal who has lived in the community for more than 17 years. instructing Karen the water technician about water usage through the watershed.

W: So, that's probably why they have to pump so much water here compared to over on Gordon Creek where Marley's flats are. I don't think that they have to pull that much.

K: Because there are organic mud type soils over there and they're wet.

W: Compared to the valley they are just pumping out the water in the valley up here. I know, it goes straight through. I know they had a lot of strawberry farms, there used to be a lot of strawberry farms in the valley. [from video recording, Open House, 1998, April 18.]

Karen is in the process of explaining a graph of water volume in the creek as it changes over the year to Walter. In this fragment his narrative fills in historical and land use detail that Karen's knowledge of soil types in the area lacks. Through these interactions, there is a mutual transformation of discourse, both the "instructor" and the "student" come away with new knowledge. In this sense we have a true participation between co-creators rather than expert and novice, which changes as people find out more about the matters of concern to the other rather than along the lines prescribed by a set curriculum.

Participating in Project Relationships

Visitors to the Open House were not exposed to a hegemonic "truth" about the scientific reality of the creek but came face to face with the relevance of the creek to the different parts of the community. Through their relationships with different presenters, each visitor had the opportunity to come away with an expanded understanding of how their community and the creek interact. This knowledge differs from what we have come to know as knowledge in the form of propositions that encode a creek and its properties (Anderson, 1985). It is a living awareness of the concerns that mediate the everyday activities of a diverse group of community members. This sensitivity to multiplicity and the concerns of others is a requisite for citizenship in an "open decent and vital" (AAAS, 1989) community.

The Open House is as much about displaying relationships as it is about making new ones. Nobody instructed visitors about the nature of the Project's relationships to other groups in the municipality. Yet there are multiple ways in which visitors would have enacted the community-based relationships that make up the project. Thus, visitors could witness the endorsement of the stewardship program by the mayor, notice students' work, admire native art, buy a plant from the nursery, or walk in the path cut through the hay fields. The many links into the community that already supported the Project provided for additional legitimacy within the municipality and allowed potential participants to experience these supporting relationships. The Open House was an opportunity for the Project to demonstrate its "good citizenship" by showing visitors who it was associated with.

By attending the Open House, talking with presenters and participating in the activities, visitors were enabled to enter into a peripheral relationship with the Henderson Creek Project. By "talking creek" with others in the presence of the artifacts, visitors were engaged in the talk of the Project. Inasmuch as they are engaging in authentic creek talk with a Project member, visitors become momentarily a legitimate peripheral part of the watershed project.

The participatory, equitable heterogeneous and situated nature of the relations that people participated in at the Open House foster a relevant and complex understanding of science in the community. Relevant because visitors engaged in co-creative interactions, where they had an active hand to play in forming the discourse. These interactions made the event complex because the creek was embedded in multiple understandings and concerns of different individuals, the people who discussed these concerns were also known to be associated with different parts of the community and these associations have salience to visitors. So people have an experience of engaging with multiple representations of the creek embedded in a network of relations that give these representations another layer of meaning. In this case, science is providing a common thread for a group to enter and demonstrate some of the network of relations that support a community.

Stewardship Triad

In the first section of this analysis, the activists' use of space to integrate the creek into other community discourses was focused on. In the second, I argued that the Open House provided a site for multiple meaning makings, multiple relationships complexifying the creek. Both of these functions stand apart from the traditional notions of creating "disinterested observers," who generate accounts of "objective reality." I in fact argue that they are important mediational practices to integrate science into "good citizenship." In the following section, I deal explicitly with a major practice of good citizenship, moral discourse.

I consider morals and beliefs to be products of talk about such things, rather than entities in themselves (Potter and Wetherell 1987). Thus, participating in discussion of what is the morally right thing for a community to do is engaging in moral citizenship. By saying this, I do not mean to exclude the many other actions that could be considered moral citizenship. At the Open House, though, and so far in the Project, stewardship has predominantly been a discursive activity. Stewardship talk is interesting to me because scientific discourse is used to frame talk about "good citizenship." Thus, people were actually engaged in science based good citizenship praxis, at a site where science, education and citizenship converge. In the following analysis, I focus on rhetoric of stream stewardship. Stream stewardship is presented by the Project to the community as, among other things, a morally laudable activity. I delineate how they engage scientific discourse in their efforts to persuade people to "do the right thing."

During stewardship discourse (both written and verbal), the "stewardship triad" was a prevalent theme. This triad linked individual actions (stewardship), science (the creek as an ecological entity), and morality (for the good health of all). The "stewardship triad" is an example of a thematic pattern that the activists use to engage community members in talk about doing stewardship on their private property. It consistently has all three elements: science, morality and stewardship, and is prevalent throughout their talk

and text.¹³ It is an example of science shifting from the epistemological realm to the ontological, “dissolving” into the fabric of everyday conversation (Irwin, Dale, & Smith, 1996, 61-64). While classic science claims to take an objective, value-free stance of the disinterested observer, the activists integrate morality into scientific discourse. The presence of all three elements is evident in the following excerpts (Figure 1).

¹³ Interestingly, government stewardship brochures tend to also include an economic facet to the stewardship triad, claiming that protecting our resources is good for the future economic well being of the community.

From a newspaper article:

MacDonald emphasizes that the aim of the project is not to just restore a creek, but to create a means for community awareness and action, creating a local commitment to long-term sustainability that will continue long after [their] work is finished.

“This project must be driven by the community. *Once residents understand the issues and problems in the watershed and in the Saanich inlet*. I believe they will be committed to ensuring the health and integrity of the *natural processes* that sustain us all.”

From Project’s Stewardship Brochure:

There are many benefits to taking part in a stewardship program. In the longterm, you can take pride in assuring a healthy ecosystem, and a clean, adequate water supply for future generations.

From the Project’s Website:

Every watershed resident influences the *health of Hagan Creek*, so whether you live along the *creek or tributary*, work in Keating Industrial Park, or live in a residential area, you can play an important role in protecting the *creek system and the watershed function*.

Figure 1. A discursive triad linking scientific terms, stewardship practices and good citizenship is prevalent in written and spoken discourse about the Project’s stewardship initiative. Different parts of the triad are indicated by differently shaded text boxes: words and phrases associated with stewardship are boxed, those associated with citizenship are underlined, and those associated with scientific literacy are *italicized*.

I suggest a “stewardship triad” whose elements include stewardship activity, knowledge generated by scientific research, and moral responsibility for the health of the community. The moral responsibility is portrayed as the natural consequence of being informed of the scientific knowledge. The Project’s administrator Meaghan stated in an interview (Figure 1): “Once residents *understand* the issues and problems... they will be *committed* to ensuring the health and integrity of the *natural processes* that sustain us all” [my emphasis]. Understanding of scientifically articulated issues and problems is portrayed as a springboard to a moral commitment. She makes the subject of the citizens’ commitment the “integrity of natural processes,” an ecological phrase. Meaghan wove a tight relationship between a scientifically legitimate worldview and moral commitment to a healthy world. In stewardship talk, reference to relevant actions by a morally responsible, scientifically aware citizen completed the triad. In Figure 1, we see that “they will be committed to *ensuring*” the health of the community and natural processes. Thus stewardship activity flows naturally from a moral agent’s understanding.

This “stewardship triad” is a thematic pattern¹⁴ (Lemke, 1995) which is basic to the stewardship discourse of the activists.¹⁵ What can this tell us about the activists’ scientifically grounded discourse? The first thing we note is that they use, in this case, science as an authoritarian version of the truth. “Natural processes,” “healthy ecosystem,” and “clean adequate water supply” are all treated as entities, rather than ill-defined sites of conflict. The uncertainty or deliberations around the construction of standards, so often an issue in the science studies literature (Alder, 1999; Star & Griesemer, 1989), are virtually absent. The second is that they construct a moral agent whose main concern is with the well being of the whole, not just community, but “web of life.” Embedded in the activists’ arguments is a moral stance that puts primacy not on the fate of the individual or even of the human inhabitants, but on the functioning of the natural processes and health of the ecosystem (and by doing so assumes they can be known objectively). Finally, the activists describe a moral agent who is empowered financially and intentionally to work to bring about change in their way of living, so that they now fall in

¹⁴ Thematic patterns are patterns that ‘recur from text to text in slightly different wordings, but recognizably the same... I take these thematic patterns... as the irreducible units of text meaning’ (Lemke, 1995, p. 42)

¹⁵ Although our figure deals exclusively with written discourse, this triad is also a feature of the Project members’ spoken discourse.

line with the scientifically mandated practices, for the good of the system. Thus, from an objective science, moral judgments and actions flow naturally.

The critical scholar is now left in a quandary; how is it that a group enacting a democratic science returns to the hegemonic science in order to ground its claims for democratically based cultural change? How is it that moral judgment grounded in a radically collective worldview is expressed in terms of individual action? This conundrum becomes less confusing if we return to notion of practice and ask, “What do the activists try to achieve with this talk?” They use scientifically legitimized arguments to convince others that becoming a steward of Henderson Creek is a valuable activity. In the case of the stewardship triad, then, it is appropriate to frame their moral arguments in ways in which the largely right-wing¹⁶ and middle-class community understands (d’Anjou & Van Male, 1998). This argument re-emphasizes that science (in this case scientific discourse) is being used as a tool to achieve a certain goal, just as it is in other aspects of life, whether it be cancer research or water quality monitoring.¹⁷ In this case, scientific discourse is enrolled in the cause of moral arguments put forward to persuade a community to take action. Thus it is part of the Project’s work to bring science into the everyday life of the community.

Education, Science and Citizenship

Returning to the overarching interests of this article, I ask whether such open house events contribute to the education of citizens who are more able to participate in democratic citizenship? Could this and similar events be considered to be contributing to scientific literacy? How can we see this case study as an instantiation of social change and cultural re/production? In considering answers to these and similar questions I ask readers to compare the kind of science education that is made available to school students and that available to visitors of an open house. In schools and universities students generally face one version of science. This version of science is usually disconnected

¹⁶ In a recent national election, the majority of the votes in this community went to a candidate of a political party that stands for massive tax cuts to business, decreased spending on social programs, and that is associated with religious fundamentalism and whose leader believes that the universe was created 5,000 years ago.

¹⁷ Helford (1999) also pointed out that activists would position themselves relative to a hegemonic science in order to appeal to those whom they were trying to convince.

from other concerns such as ethico-moral, economic, or political ones.¹⁸ Science in a community-based open-house event is diverse, invites participation, and is deeply embedded in the multiple concerns of the community and its members.

For a day, the Project has physically and socially constructed a community that embodied the discourses and concerns it is attempting to promulgate to the greater community of Oceanside. The creek, as an ecological entity, is represented in numerous ways, scientifically, historically, artistically, and in relation to citizens' everyday practices. The landscape is altered to invite people to experience the creek directly. Talk is structured around moral concerns grounded in scientific characterizations of the creek's needs. Many different communities of practice have converged at a single site and socialize, weaving new associations between the creek, watershed and locality. Local governance is present and asserts its support of scientifically justified interventions in people's dealings with water. The Open House is an authentic "condensation" of many of the relations and activities that the activists engage in. Their vision of a "decent, vital society" is embodied, for a day.

Those who come to participate in the Open House become immersed in this social material arrangement and are transformed while at the same time transforming and creating the society in which they are, for the moment, immersed. Inasmuch as the nursery manager knows how to cultivate literally hundreds of native plants, Karen (the water technician) has worked with the region's waterways for years, and Project members have post-secondary (some graduate) degrees in science, this site is an excellent opportunity for people to acquire or to enhance scientific literacy. I want to emphasize, however, that this literacy is discursive, as discourse is the predominant activity that people engaged in at the Open House. In this space, literacy goes beyond being able to recite canonical facts, but includes the use of scientific talk and concepts to make more connections between elements of people's lifeworlds. From this nexus, people walk away, but they are transformed. They may be sensitive to the creek, even if it means knowing that it exists, they may have volunteered for the Project or signed up as a

¹⁸ Instructing science educators, a traditional science literacy advocate argues against involving students in "real world" issues: "Practical problems are often very complex, and variables identified are almost impossible to isolate or control....The range of problems, issues and concerns could easily spread into areas beyond the natural sciences, leading to a blurring of distinctions..." (Aldridge 1992, 18)

steward. And the presenters and the Project are also transformed, learning new details about the creek in the community, making new relationships. Thus, the Open House, as an event, was itself a moment of cultural change (production).

Through constructing and enacting this authentic community of practitioners, the Project offers many opportunities for visitors' changing participation. This has great relevance to science as it is enacted in a community during democratic process. During committee meetings and presentations to council, citizens are faced with even greater variety of discourses, thematic patterns and arguments that assimilate scientific claims. Familiarity with the kinds of rhetorical genres and representations that are employed is a necessary part of local decision making. For some, it will also serve as a starting point in a trajectory of participation, leading to a greater involvement with scientifically grounded practices in the creek, in service of watershed health and the "common good." Therefore the practice of engaging with others over various inscriptions and using multiple genres is closely related to the practice of good citizenship.

The Open House did not however, attempt to present all the uses, representations and communities of practice associated with Henderson Creek. Developers, engineers, and others who consider Henderson Creek a segment of the storm drain system, a drainage ditch or irrigation source were not invited to the Open House. Their representations of Henderson Creek constitute only its physical and anthropocentric aspects, and do not address its biotic needs or qualities (Lee & Roth, 2001b). These discourses, for the most part institutionalized in bylaws and drainage plans, are those that the activists seek to supplant with their ecology-based approach. The Project is politically positioned, striving to insert its concerns more extensively into those of the community as a whole. This does not however, invalidate the Open House as a site for learning. As has been amply shown in many studies, science is always politically positioned. (Latour, 1997), and even a school-based education comes from a (hegemonic) stance (Roth & McGinn, 1998). This educational event was therefore authentic in another sense: it accurately portrayed science at work, in this case creating and buttressing the Project's political position.

The Project is politically positioned, engaged in the act of constructing new meaning-making connections, and has brought many otherwise spatially dispersed actors

into one space for a day. Into this space, transformed to highlight scientific: social relations in the community, visitors are invited. These visitors experience a social landscape charged with political and community affairs discourse. shot through with scientific discourses such as those about “groundwater,” “aquifer.” and “watershed.” By walking talking, pointing, they involve themselves in these discourses. learn how to interpret representations. and form new relations with other community members. I have shown some of the complex ways that citizenship and learning can be intertwined with science and enacted at such a site.

Chapter 10: Monoglossia, Heteroglossia, and the Public Understanding of Science: Enriched Meanings Made in the Community

This piece was written in the winter of 2000/2001, and submitted to the journal “Configurations” in March of 2001. “Configurations” is an interdisciplinary journal of science, literature and history. The journal has a theoretical bent, many of its articles are concerned with the appropriate way to theoretically frame the topic under discussion.¹ This article was therefore written for an audience interested in both the topic and the work of theoretical framing.

The article is an attempt to use a particular kind of framework of literary theory, Bakhtin’s dialogic analysis (1981a; 1986), clarifying some salient aspects of meaning making at a public meeting. While reading Bakhtin (1981b; 1981c; 1986) to deepen my understanding of activity-based semiotics, I was struck by how his conception of language as part of social struggle was relevant to many of the struggles I experience between “untutored” ways of articulating the world and scientific ones. He was a linguist who adopted a sociological view to language, treating it not as some transcendent structure (like so many linguists do), but as always involved in specific acts of communication. From this perspective, language is very “live,” and irrevocably entangled in with speakers’ social worlds, histories and the place in which it is uttered. Bakhtin also wrote quite extensively about disputes over “conceptualizing discourse” between the ruled and the ruling classes. I considered this theoretical model to be an excellent way to write about the disputes over water supply I participated in. The data seemed well suited to the analytic style. I had a transcript of a public meeting, had participated in doing research for one of the actors in the controversy, and knew background information about a number of the speakers, so could write about them in sociological terms. In this situation, residents’ experience is put up to the scientific test, and the residents’ put the science up to the test of their experience. Bakhtin’s theory helps me to describe the

¹ For example, Lynch (1994) writes about the mis-use of the term representation, Lenoir (1994) writes a critique about specificities of the semiotic framework employed by many STS writers. Anatolii Akhutin and Vladimir Bibler are interviewed about correct interpretations of Bakhtin’s contributions and so on (Alexandrov & Struchkov, 1993).

situation without granting one side or the other the “rational” position or a priori giving their voice primacy

The data analyzed is a transcript of a two hour long public technical meeting. I had prepared some background for one of the sides, so had researched the history of the dispute and had a lengthy interview with the main scientific critic on one side. I obtained copies of all the official reports and documents involved up to that point through the help of the municipal administrator who was mediating the dispute. I also took field notes after I attended the public meeting and for the two weeks while I prepared my presentation.

Thematic Issues

More than any other, this chapter confronts the relationship between science, authority, and claims to knowledge (literacy, democracy and representation themes). Its purpose is to work out a way of talking about conflicts where science has a role in defining or deciding the problem and or the solution, but where others’ ways of knowing may also be important parts of the problem or solution definition.

The analytic focus of this chapter is on verbal representations. These verbal representations were situated in the communities of practice from which they emerged, the situation in which they were spoken, and the work these representations could be argued to be attempting to do. The goal was to re-frame the representations of the scientists and lay populace in such a way as to encourage a more equitable distribution of power between them. Bakhtin’s notion of “hybrid” constructs, each “interilluminating” the other and transforming its meaning, was adapted to this scenario. In this case, de-contextualized scientific discourse must work to make itself meaningful to a community.

Like the “Ditch and Drain” chapter, the focus of this chapter is less on specific relationships and more on relations between people and institutions, humans and non-humans, discourse and environment, and others. Although relations between and among entities are emphasized, I do not develop the relationship side of science to the same degree as in other chapters.

This chapter represents the final development of the notion of the sociologically embedded nature of the representation. Themes of relating representations to

communities of practice begun in “Remapping the Landscape,” developed in detail in “Science and the ‘Good Citizen’” are here taken one step further by correlating social heterogeneity with representational heterogeneity. The link between sociality and representation is culminated with the appropriation of Bakhtin’s (1986) terms “monoglossia” and “heteroglossia,” which explicitly make connections between acts of communication and the communicators’ sociological position. The term “hybrid” representation is developed. Mentioned briefly in “Ditch and Drain,” a hybrid representation is a single representation in which both the different communities’ voices are present. It is presented as a way to make sense out of the often confusing claims made by parties in conflict about natural resource allocation.

A new approach to situating meaning making in a specific event is introduced in this chapter. A re-representation of both scientists’ reductive and residents’ complexifying discourse is performed in such a way as to treat both with respect, and in a manner appropriate to their limits and potential uses.

Monoglossia, Heteroglossia, and the Public Understanding of Science: Enriched Meanings Made in the Community

Introduction

All languages of heteroglossia, ... are specific points of view on the world, forms for conceptualizing the world in words, specific worldviews, each characterized by its own objects, meanings and values. (Bakhtin, 1981a, p. 291)

Languages throw light on each other ... there is no more peaceful co-existence between territorial dialects, social and professional dialects and jargons, literary language ... and so forth.

All this set into motion a process of active, mutual cause and effect and interillumination. Words and language began to have a different feel to them; objectively they ceased to be what they had once been. (Bakhtin, 1981b, p. 12)

In these quotes, Bakhtin offers a framework for understanding some of the transformations that science undergoes as it travels from research institutes and laboratories to other sites, such as people's homes and local communities. It suggests that struggling to impose a single ethnocentric discourse, for example that of "sound science," is hopeless in such a rich context. Instead, we are invited to appreciate the new meanings that emerge as different ways of speaking about the world meet and interilluminate one another.

Heteroglossia is the situation where many languages co-exist in a social space, and co-exist in a way that mirrors the different sociality of the speakers. Thus it is a way of conceptualizing diversity, both of language and the social struggles and ongoing transformations within which the languages exist. I aim to make an argument for the public uptake and use of science as one such site of interillumination. In doing so, I follow the discursive transformation of scientific representations as they travel from laboratories and bureaucracies into the controversy surrounding proposed solutions to one community's water crisis.

This approach is different than that being used in many of the complex technoscientific issues facing the world today, where people are engaged in struggles about the role that science should play in solving greater societal concerns. Often in these controversies, work is done to distinguish “scientific” or “rational” from “non-scientific, irrational” thinking. In the process of doing so, those “irrational” agents become excluded from meaningful participation in decision making processes (Brown & Michael, 2001; Wynne, in press).²

I am not interested in producing excluding and disempowering discourse. Instead, I am interested in the creative potential of new ontologies that emerge from the conflict between previously isolated communities.³ This chapter, then, works to articulate what lies within the zone of tension, in situations where the modernist settlement of rational/scientific and irrational/non-scientific boundaries are not yet set or do not have their usual power.

I analyze a transcript from a public technical information meeting, featuring presentations from both experts and the affected residents, about a controversy over the quality of the residents’ drinking water. I treat this transcript, containing testimony and arguments from both scientific experts and residents, as the trace of a heteroglossic struggle, and bring concepts developed by Mikhail Bakhtin in his analysis of the novel to bear on it. I apply his theoretical constructs of the dialogic nature of the utterance, the concept of hybrid meanings, and the struggle between the heteroglossia of the masses against the monoglossic⁴ word of (scientific) authority. By applying the analytic tools of this literary theorist to this text spiked with scientific terminology, I move beyond discussions of right and wrong and highlight the sociological relations within which the text is embedded and which it re-creates. This style of textual analysis allows work to be done within a situation where the boundaries of “scientific” and “non-scientific” are not

² Many STS scholars have worked to show the links between scientific “expertise” and authoritarian power. In particular, they point out that by excluding some people as “irrational,” those allied with authorities who claim rationality or expert knowledge are able to wield political authority by excluding the views and opinions of those others. For examples, see Irwin & Wynne, (1996).

³ In making this claim, I draw on the tradition in STS scholarship that claims that social/material arrangements do not only give meaning to the actants, but also define their *being* at a particular time and site. Some works which discuss this “ontological semiotics” include: Mol and Mesman (1996) and Law and Mol (1995).

⁴ Monoglossia refers to a speech genre or language that comes from a homogenous community.

stable. They help to make sense of a scientifically difficult research problem and bring out the generative aspects of the work done by “non-scientific” residents in their challenges to decisions imposed on them from absent authorities.

In this chapter, I foreground the creative and generative potential of new relations that citizens bring to discourse about scientific and technological issues. In the midst of a community struggle over resource allocation, people make arguments, fusing scientific terms with economic, historical or moral ones. Scientific discourse is taken up and recontextualized with other discourses of daily life concerns, interilluminating one another in new hybrids of meaning. New non-humans, familiar to residents’ everyday life, are recruited to speak on behalf of the natural world, and work is done to demonstrate the socially constructed nature of science. Citizens create new meanings, which incorporate scientific data and arguments along with arguments that make sense in the temporal and local context of the controversy.

In fact, I argue that we should consider this new meaning making as the expected outcome of scientific utterances⁵ travelling to and being taken up by different communities of practice.⁶ This struggle is a necessary process for adding local meanings to those data that come from a distant locale (anonymous scientific laboratory) and from a limited social milieu (scientific). As scientific graphs, charts, and discourse move from labs to community fora, they become exposed to and incorporated within a much more complex community than the one from which they originated. And it is within this new community that they must have persuasive meaning and be translatable into more substantial social/material hybrids such as water mains. Thus, the discourse in a public meeting is not to be associated with “wrong thinking” or irrationality, but with new creative work that must be done to absorb science into different communities of practice. Like Bakhtin, I argue for the necessity to embrace and engage this onslaught of meaning

⁵ “Utterance,” as Bakhtin used it, denotes a communicative act bounded by a change in speaker. This does not restrict “utterances” only to verbal situations. An utterance can be a turn taken during a conversation, or an essay (Bakhtin, 1986, p. 71).

⁶ “Community of Practice” is a practice theory term, which refers to a community of people defined through their participation in a certain practice. Although this term has come into use after Bakhtin’s death, it has a close relationship with the notion of ‘speech genre’, which is a term that Bakhtin used to describe the idiosyncratic vocabulary associated with among other things, communities of practice. In this paper, I consider that communities of practice will bring specific genres to events in which they participate. It is this mixing of heterogeneous genres that creates a heteroglossic situation.

making and rearranging of boundaries if we are to begin of overcoming the power relations that keep science from fully supporting, and indeed becoming absorbed into, a democratic process.

Context—A Quarrel over Water

This analysis arises out of an ongoing controversy that has been an issue in the small quasi-rural municipality of Oceanside for over twenty years. Some residents who live in the community of Dry Point (within Oceanside) experience problems with the quantity and or the quality of the water from their wells. The water is bad tasting and is in insufficient supply during the dry summer months. In the past, the municipality of Oceanside had promised to redress this issue, preferably, to the residents' point of view, by building a water main extension which would bring treated water from the village⁷, six kilometers away, to their homes. This has yet to happen, and the most recent town council has balked at taking the residents' preferred action.

Dry Point community members' concerns arise from the confluence of geology, climate, politics, and the expectations of affluent homeowners. The community is built on granite bedrock. Well water comes from underground fissures in the bedrock which collect rainwater. Different geologic formations yield water in differing amounts and with differing chemical constituents. Thus there is a great diversity in water quality and quantity⁸ depending on the specific 'pocket' of water accessed by any one well.⁹ The fact that their wells are relying on rainwater for recharge renders the homeowners' water supply very sensitive to the annual weather patterns. Oceanside enjoys a Mediterranean climate, often with little or no rain in late June, July, August, and early September. As the summer wears on, both the quantity and quality of residents' water decreases. Because Dry Point is in a rural area,¹⁰ the municipality is not obligated to ensure water service.

⁷ The village pipes in treated water from the large urban center fifteen kilometers away.

⁸ For example, well flow volumes range from 0.5 to over 100 gallons per minute.

⁹ The science of this situation is complex. Because the "aquifer" is a fractured bedrock aquifer, with unknown mixing between the fractures, it is impossible to get any one water sample that could be considered representative of some larger body of water that could be used to describe a situation at a specific well. And because the well water is always changing volume as the seasons change, it is impossible to get a reading that represents the water quality for any one well per se, as the water composition will most likely change by the next month, if not in the next few weeks.

¹⁰ Residences in rural areas are expected to use groundwater.

The residents have no legal recourse to enforce the help of their local government. This combination of unreliable water supply, a non-responsible (and non-responsive) municipal council becomes more of an issue when we take into consideration that many Dry Point residents are well off and do not want to worry about water problems. Unlike many neighboring farmers and people in other parts of the world, they describe their access to 250 liters a day of city water¹¹ as their “God given right.”¹² While acknowledging their choice to move to this isolated place with no municipal water supply, they do not want to live with the water situation as it is.

The Water Advisory Committee (WAC) was struck by the municipality to address water issues in the municipality in general and Dry Point in particular. The WAC has repeatedly recommended that the residents individually treat their well water rather than having the community build an extension to the water main. Suggested strategies for individual treatment include storing water in cisterns, mitigating chemical impurities and disinfecting if need be. This approach is in direct opposition to the residents’ desire and is not even supported by all members of the committee. Three of the seven members resigned before its recommendations were published. Thus the official body created to help resolve the issue is both divided within itself and stands in opposition to the residents.

In the spring and summer of 1999, a total of six reports addressing technical, scientific and policy issues around the water crisis at Dry Point were produced. At a council meeting in August, the mayor of the municipality called for a public meeting to be held, where all the writers of the technical and scientific reports could gather in one place, present their work and respond to comments from the general public. It would also be a place and a time for the residents and other members of the municipality to present their arguments for a solution.

The public hearing was held in the fall of 1999. A member of the municipality’s engineering staff was in charge of moderating the hearing. He structured the hearing in the following way. First, the authors (or representatives) of the reports were asked to

¹¹ This is the average water consumption of a Canadian.

¹² Dry Point Public Technical meeting transcript, p. 30. In all subsequent references to this transcript, I simply use the abbreviation “ST” followed by the page number on which the quote was found. For example, this reference would be indicated by “ST30.”

summarize the findings. The presenters included Randall Burstead (representing the local health authority CHR), Dan Logan (a hydrogeologist hired as independent consultant in the case), Marcus McGill (representative of the Water Advisory Committee report), Rick Redfern (representing the dissenting report prepared by the members of the WAC in disagreement with the original document), and the moderator (representing the municipality). Then, members of the community were provided with an opportunity to ask questions about the technical matters just presented by the previous speakers. Finally, time was allocated for community members to speak about their concerns related to the water on their own terms.

The public meeting is a particularly fruitful site for the analysis of science at work in the community. There is no hegemony, politically, or scientifically, which can be counted on to simplify the situation and avoid due political process.¹³ Science is being enacted in a situation where it is not *de jure* fused to authority or power. In order for their discourse to to garner resources, the actors must perform a convincing, compelling narrative about the reality of the situation. In this persuasive work, scientific discourse plays a central, but not exclusive role. It is an excellent example of a situation that STS scholars might consider an ideal type, where science is but one of the discursive repertoires being used rhetorically, and its importance cannot be taken for granted but has to be established through argument.

I treat the transcript of this session as Bakhtin treated literary work—as part of a historically constructed, ongoing conversation.¹⁴ I confront the heteroglossia of the situation and draw out its creative aspects. Bakhtin's well-developed sociological analysis of multivoiced texts helps to link text to community, to history and circumstance, bringing out the substantial creative work done in the zone between local and scientific knowledge. In the following section, I analyze the public the meeting as a heteroglossic struggle against a monoglossic, authoritative representation.

¹³ Here I mean “due political process” in the sense articulated by Latour, as an open discussion over whose reality will form the basis for collective decisions. (Latour, 1999b, pp. 293-300).

¹⁴ Having said that, I acknowledge that an analysis on the historical scale of a truly Bakhtinian one is well beyond the scope of this text.

Scientists' Talk and Residents' Talk: Authority and Resistance as Cultures Collide

In community-level science, arguments among experts are not the only persuasive arguments that matter. Local residents also work at interpreting and re-interpreting scientific data. This public forum is often a source of great difficulty for scientists, who hear their data “misrepresented” or “misunderstood.” In the following sections, I work to create a level playing field for the community members by situating both the monoglossic discourse of the scientists’ and the residents’ discourse in historical and sociological terms. Through this kind of a representation, I shed light on the work that both types of talk are doing without valuing a priori one over the other. First, I situate the struggle within a greater scenario—that of the conflict that “just plain folks” face when they attempt to affect the outcome of scientific controversies.

Some typical discourse about nature of “grass-roots” issues and science is found in the following statement by a national leader of American science-education policy who cautions against involving students in “practical problems.”

The range of problems, issues and concerns could easily spread into areas beyond the natural sciences, leading to a blurring of distinctions in areas where such distinctions are very important, such as between science and technology, or between science and philosophy and religion. (Bill Aldridge, cited in Eisenhart, Finkel, & Marion, 1996, p. 281)

These reasons are no longer valid excuses for bypassing or trivializing the concerns of citizens involved in techno-scientific issues. Citizen participation in decision making is increasing. In the US, it is acknowledged that for resource management policies to have achieved their targets, they must be products of community process and not merely science based (Goldstein, 2000). In this sort of decision-making climate, a solution’s “robustness,” that is, its acceptability to numerous stakeholders, and the likelihood of its political efficacy rather than its scientific correctness, becomes paramount. In both Europe and the United States, we see many instances of increased democratic participation in science-related matters (Rowe & Frewer, 2000). But just because citizens’ panels are convened and public process is invoked does not mean that the “uneducated masses” are significantly contributing to science policy. In these fora,

work is often done to distinguish “value-based” issues often attributed to the public, from expert issues, which only the scientists are able to comment on. Brian Wynne (in press) argues that this framing constitutes an exclusion of the public from true participation by marginalizing the public’s input away from substantive decision making. Brown and Michael (2001) show how scientists work from one linguistic register, that of “expert,” to another, which could be called “plain folks,” effectively marginalizing public oppositional groups by doing so. This exclusion of non-experts from decision-making power on the grounds of their “scientific illiteracy” is a familiar theme to readers of STS literature, and there have been many excellent studies and persuasive arguments against this exclusion. Rather than provide a catalogue of them, I will focus on one account by Bruno Latour and then elaborate on the path he suggests.

In “Socrates and Callicles Settlement, or the Invention of the Impossible Body Politic,” Latour (1997) reframes an old story that has commonly been construed as a morality fable about the importance of using reason, not force, when ruling a people. Callicles claims that possessing superior might justifies ruling others, while Socrates argues against this, claiming that reason is the only moral avenue through which to properly control the people. Latour, in his reframing, suggests that this is really a non-argument, and that more important than Socrates’ and Callicles’ disagreement is their agreement that the masses are in need of some sort of imposed rule. Although Callicles is traditionally viewed as representing the side of the argument that we should reject, Latour points out that Socrates does no better than Callicles in terms of democratic process. Socrates’ suggestion of controlling the demos through reason was still a political shortcut, a way of avoiding dealing equitably with the multitude of voices and concerns that a populous brings to political problems. “[Socrates’] settlement had a great appeal ... because it seemed to offer the fastest way to transform the ‘unruly shambles of gods, heaven, and men’ into an ordered whole” (Latour, 1997, p. 239). Latour then relates this settlement to the use of science in defining the parameters of our shared reality without due political process. His challenge to the reader is the question of how can science contribute to democracy, embracing the “damned tendency of the mob to discuss and to disobey,” (Latour, 1997, p. 239) rather than being used as a shortcut used to de-legitimize and exclude another group’s concerns?

Mikhail Bakhtin, in his historical work on the development of the novel, sheds some interesting light on this problem, particularly by articulating some of the means by which the ‘unruly mob’ resists authority. In the essay “From the Prehistory of Novelistic Discourse” (Bakhtin, 1986c), he frames a struggle between the many voices, including those of the “lower” classes (he used the term “heteroglossia” to describe this multiplicity) to overcome the “lofty direct word” (“monoglossia”) of authority (Bakhtin, 1986c, p. 55). Monoglossic discourse “deals only with the subject [it] represents, or expresses, and... does so in...language that is perceived as the sole and fully adequate tool for realizing the word’s direct, objectivized meaning” (Bakhtin, 1986c, p. 61). Thus authority speaks directly about an objectivized, complete world, not unlike the rational “Science No.1” of Latour’s work (Latour, 1997, pp. 231–240).¹⁵ At the public meeting, this type of discourse could be found in the reports of the scientists who claimed to speak authoritatively about water quality (see the “Monoglossia” section below).

Resistance to this direct word is evidenced by the occurrence of its re-representation by those who would be subjugated by it. Re-representation of the representation of the utterance of an Other includes a comment, by the re-representer, on the Other’s position to the original object. Discourse, now, is no longer directly about an object but “toward another’s word as well” (Bakhtin, 1986c, p. 61). Thus when we imitate another’s language in a group of friends, we can mock, laud or “impartially report” the other’s word, but our stance to what they have spoken is always included within this re-representation. This way, a statement about the world takes on a second voice, the voice and viewpoint of the person doing the re-representing, and with this second voice, there is a chance for new meaning (Bakhtin, 1986c, pp. 41-83). This opportunity for creating new meaning is the key, in Bakhtin’s view, to resistance.

Writing about the “parodia sacra,” a tradition of parodies of sacred Latin texts written in Europe during the Middle Ages, Bakhtin states:

The sacred Latin word was a foreign body that invaded the organism of the European languages. And throughout the Middle Ages, national languages, as organisms, repulsed this body. It was

¹⁵ Latour distinguishes between a sure, rational, law-based “Science No. 1” and a contingent, controversial, evolving “Science No. 2.”

not, however, the repelling of a thing, but rather of a conceptualizing discourse that had made a home for itself in all the higher reaches of national ideological thought processes. (Bakhtin, 1986c, p. 77)

I wish to emphasize his contention that this struggle for expression is a struggle to control the “conceptualizing discourse”—the activity by means of which a society frames its problems and priorities. I am interested in Bakhtin’s framing of a struggle over conceptualizing discourse through various ways of re-representing another’s word. In my view, conceptualizing discourse can take the form of sacred Latin texts or legitimized scientific representations. By framing public participation in scientifically rooted controversy in terms of a heteroglossic struggle to shape the conceptualizing discourse of the day, I make sense of “the damned mob’s” participation in scientifically informed issues.¹⁶

Bakhtin wrote about discourses of domination and resistance he saw being played out in the parodic texts of the Middle Ages and in the novel as an emergent form, so he framed much of his commentary on the importance of laughter, parody and irony. I also see this activity in our transcripts. Residents skillfully poke fun at the Water Advisory Committee and its sober rational approach. They make new meanings of the Water Advisory Committee’s results by juxtaposing scientific with sociological, historical, and personal points that weaken the Water Advisory Committee’s position as neutral servants of the community. But I also encounter positive work done by residents to win the struggle to articulate the “conceptualizing discourse” around the water controversy. In whose language does the problem become stated? Whose non-humans are legitimate reporters? Where are the problems to be located? These are the issues at stake as the resident homeowners attempt to make their stories the ones upon which policy will be built.

In the following section, I briefly analyze “monoglossia.” What are some of the social/material features that I can identify as co-existing with and supporting a monologic discourse? Then, in “Heteroglossia,” I argue for the work that the community members do

¹⁶ In Brian Wynne and others (Irwin & Wynne, 1996) also point this relationship out in “Misunderstanding Science.” Bakhtin’s framework allows us to articulate this representation clearly and go into a more in-depth analysis.

to de-stabilize the “authoritative” monoglossic claims put forth as “rational” and “systematic” by the WAC. What kind of new associations do the scientific results find themselves in? What kinds of non-humans are recruited to report water quality? Where is the data taken from, what activities does it pertain to? I describe several kinds of work that the residents do, and by doing so, hope to show that this “confusing mess” is really a creative force. I sketch some of the “damned mob’s” tendencies in an effort to legitimize their voice and contribute to a more democratic political process.

Monoglossia – the “Direct Lofty Word” of Science

Each of the languages of heteroglossia ... is grounded in a completely different principle for marking differences and for establishing units. (Bakhtin, 1986a, p. 291)

In the previous section I described monoglossia as “the direct lofty word” of authoritative discourse. The world is spoken of as a direct object, and this discourse is considered as a “fully adequate tool” for realizing meaning. Scientific discourse as practiced in the public forum has many of the features of monoglossia. It is considered to be a discourse that speaks directly about the world, and as such is the appropriate tool on which to base policy decisions. In the following section, I elaborate on the above quote and treat the monoglossic word as one of many, albeit a special case, in a heteroglossic situation. I discuss some of the sociological features, some of the usually invisible practices that contribute to its monoglossic character. Through our discussion, I expose some of the social material arrangements that support monoglossia, and prepare the ground for our discussion of the residents’ heteroglossic resistance.

In the first part of the public meeting, two experts debated over whose direct word would come to stand for the aquifer. Dave Logan, hired by the Water Advisory Committee (WAC), argued that his methods of sampling were a substantial improvement over those used by the local health authority (CHR). He claimed that by bypassing household plumbing, and by a judicious choice of sample locations, diversity of well types sampled, and time of year when he took samples, his measurements of water quality indicators were representative of the aquifer as a whole. In this, they were valid enough to make the political decision to not fund a pipeline. Randall Burstead,

representing the CHR, argued that Logan's data was not substantially methodologically different from those collected by his organization, and that the differences in water quality between the two sampling episodes was due to fluctuating water levels in the aquifer. Based on their sampling episode, the CHR scientists had previously declared the water of Dry Point to be unpotable, and recommended building a pipeline to the community. The residents supported these conclusions, whereas the WAC (a municipal committee) opposed them.

The results of water testing, handed down by the experts as representations for the aquifer were "the direct lofty word," taken to stand for an objectified reality, namely, the pool of water from which the residents draw. In their discourse, the graphs they present are said to stand for the aquifer: "there's two years of water levels taken at that well and they show the peak of the water levels and the troughs and they show that water levels would be ... average." [ST6] The statement is factual and decontextualized. It could be about any body of fresh water. It is the monoglossic discourse with which scientists are comfortable. Below, I re-frame their authoritative words in terms of the social/material entities that help form them. Thus, I shift the meaning associated from this voice in the community debate from "the truth" to "a voice from a specific place." This in turn lays the groundwork for our analysis of the residents' talk, which I can treat as a voice from another place. In this way, I achieve a more symmetrical analysis.

Facts and findings, method and variables are discussed among a community of people who share understandings, know the non-humans involved, and understand the representations in culturally shared ways. The representations only need to function in the limited social milieu of hydrologists and water quality engineers. I take this isolated community from which the results emanate to be also an important source of the unity of the speech.

Many of the non-humans, such as chromium or bacteria, are invisible in our normal daily lifeworld. Many others, such as spectrophotometers, pH meters and bacteriological testing procedures are foreign to most peoples' daily world. The monoglossic word is emanating from a source of "invisibility" to most people. Machines the residents are unfamiliar with are measuring substances they cannot see. Residents have no independent means to measure the substances of interest, and most of them are

not familiar with how the substances are measured. This “invisibility” can be used to impose closure on discussion, as only the scientists can contest what actually goes on in a lab.

And these practices are taking place in localities removed from the sites where this water really matters. Samples are “sent off to the lab” for analysis. The graphs and numbers presented during the technical part of the public meeting are results meaningful in a community of practice distant to and different from the community about which the results are speaking. This distance makes the production of the results inscrutable and uncontested by the residents and adds to the authority of the monoglossic voice.

Another important part of the “lofty direct word-ness” can be found in the discursive work done by the audience and the speakers to ally the bearers of scientific data with legitimizing institutions. Before he gives any of his comments, Randall Burstead, the representative of the regional health authority (CHR), explicitly states that his comments are based on the work of an “Environmental Health Officer.” The individual has “a Masters of Science degree, and has significant experience,” and is “the Public Health Engineer serving the Capital Regional District, Central Vancouver Island and Upper Vancouver Island Health Regions” [ST3]. Burstead himself was introduced by the moderator as “the Chief Environmental Health Officer” [ST2] for the Capital Health Region. Audience members also work to establish relations to his authority by emphasizing titles and professionalism. For example, one resident said, “As I understand it, the CHR spent significant time and money over a long period of time investigating the water at multiple homes using professional engineers, professional people involved in water quality” [ST21]. The resident makes reference to a significant amount of institutional energy committed to the deployment of professional people with experience to ally the scientific findings of the region with the authoritative word, the word that should be used to mobilize resources. On the other hand, the contractor hired through the request of the WAC (Dan Logan) also makes claims to authority, mainly by emphasizing that his research was well thought out and executed—especially in contrast to the work done by the CHR. So in both cases, those who speak science talk do so while aligning themselves with an external authority, attempting to position their word in such a way as to be the authoritative description of the aquifer, from which action will result.

In this case, I note four important parts of the monoglossic, authoritative word. It is associated with a limited community of practice using an exclusive jargon. It talks about things that residents cannot see and do not know how to measure. It talks from a distant locale where the residents cannot contest the validity of the analytic approaches. And it is associated with legitimizing institutions to make the results more valid. In the course of the session, we will see all these aspects of monoglossia challenged by the residents as they struggle to appropriate the conceptualizing discourse.

Heteroglossia – the Residents Speak Up

Heteroglossia refers to a multiplicity of languages co-existing in one location. After the scientists and authorities had spoken, the residents, bringing many different types of conceptualizations of the issue, spoke. During this part of the session, they did discursive work that shifted the nature of the talk. This work introduces heteroglossia into the conversation and I ally it with Bakhtin's description of the roiling social struggle that underlies the form of the novel. Though scientific terminology such as "aquifer," "TDS," and "pH" delimits the discourse, this terminology is taken up and incorporated into new meaning mixtures. Thus the "lofty direct word" becomes someone else's representation, and loses its direct stance to an objectivized world. The recontextualization affords new possibilities for making meaning through the combination of everyday and scientific discourse. Juxtaposing scientific terms with others from their own repertoires, the residents expand and complexify the relatively straightforward monoglossic discourse foisted upon them by the authority of distance.

In the course of this meeting, I noticed numerous types of discursive work done by the residents. I analyze a number of the more predominant themes in the sections below. In "Locality," I show that they did geographical work, re-locating water quality back into their community and homes. In "Temporality," I note the temporal work done, framing the issue as defined by not just as one or two "snapshots in time," but as part of history of human interaction with a recalcitrant landscape. I discuss the residents' attempts to embody the experience of a "fluctuating aquifer" and to define water quality in terms of their familiar practices and non-humans in the section "Increasing the Community of Non-Humans." In "Socializing Knowledge Claims" I present some of

their relational work, noting how they added sociological context to the “direct lofty words” which had arrived in their community from afar. And in “Semantic Challenges,” I argue that the meaning of terms like “health” and “pipeline” were some of the most hotly contested parts of the debate.

I hold that these discursive struggles are a necessary broadening of discourse that must happen if science is to become a pro-democratic force in democracy. I argue that this stance toward public re-presentations is not a divergence that poses a threat to a clear view (confusing or blurring boundaries that must be maintained), but work that rightly so adds complexity to the phenomena at hand, including different localities from those which are represented in monoglossia. These different localities and experiences are the ones in which the science will ultimately be situated, and therefore should be included in the talk. In the following sections, I discuss each of these types of re-representation, speculating on the meaning shifts that happen as scientific discourse is taken up in service of heteroglossic projects.

Locality

As already mentioned, much of science’s authority comes from its geographical “otherness.” That is, a representation defines a place (its water quality, for example) and its possibilities for those who live there but the representation comes from some unknown locale. The following account shows how the residents resist such de-localized policy by working to localize its claims and thereby neutralizing them.

The contracted hydrogeologist Dave Logan sampled nine different sites and worked to determine an average quality. There was no other indication of locality in his talk. There was no mention of specific location in the speech by the representative of the Capital Health Region Randall Burstead’s. The chair of the WAC, Marcus McGill, framed the water quality issue with references to the greater municipality, the region in which the municipality is one of thirteen, neighboring regions and global trends.

We are a very privileged and fortunate community and the number one place to live on this place, planet.... There’s a very serious concern for a long-term supply of water in the capital regional district.... Something [...] is happening in Sechelt on the Sunshine Coast.... There is a sweeping movement in North America. [ST9]

Notably, not one of these speakers indicated any specific features of the neighborhood, let alone one of the residences affected by poor water quality. On the other hand, residents worked to frame water quality issues in a very specific locality: their own community.

One of the dissenting resident members of the WAC critiqued the majority proposal by localizing their recommendations and arguing that they were not feasible.

The community cistern [must lie] somewhere near the intersection of West Sandwich and Mount Nimbey Road. So it was high enough that it would provide gravity feed to the homes.... Who's going to provide the land, it's all private land.... Is there enough water in the aquifer to drill two or three high-volume wells that could provide the cistern? We don't know. Certainly it's not a long-term solution because the area is ringed with agricultural reserve and there are people right now who are waiting to increase the amount of irrigation. [ST10]

The speaker resists the de-contextualized arguments of the WAC about potential solutions for the summer water shortages by localizing them. Rather than by arguing against them as good ideas or bad ideas in some abstract way, he re-locates them into a local context. His factual claims about the landscape suggest that a community cistern¹⁷ may well be a commendable sustainable solution in some locales, but not in an area with farmers drawing on the aquifer to irrigate their crops or on expensive private land that would have to be purchased before the cistern could be built. The re-alignment of the community cistern, away from the "sustainability" and "efficiency" arguments of the WAC, to those of the limits of a specific location, shifts its use and participation in the dialogue of the community meeting. The community cistern had been aligned with innovation and environmentally friendly efficiency. Now, through juxtaposing it with farmers waiting to increase their water usage, with no land base on which to build it, the community cistern is exposed as ridiculous, a potential object of laughter, and certainly not a long-term solution to the water problem. Another strand in this dialogic is the

¹⁷ A community cistern was one of the WAC's recommended solutions to water quantity problems experienced by the residents. This proposed solution relied on the premise that there was no systemic problem with the aquifer from which the water was being drawn.

accompanying narrative that the WAC, despite its claims to the contrary, has not been sufficiently thorough or systematic in its work.

Regardless of the theoretical discourse surrounding the WAC-supported solutions, the effects of the decision about the nature of infrastructure changes in the community have to be endured by the local residents. They will bear the cost and expend the effort to enable the discursive solutions to become material ones. In this situation, it is right that the voices of localization be brought to bear on the implementation of the solutions proposed by “experts” in their monoglossic discourses.

Temporality

At the municipal level, many scientific inquiries are performed on a relatively short-time scale, as there are not enough resources available to support longitudinal studies. The time scales of studies can also become contested entities, especially when residents, who have lived in a region for many years, begin to contribute to the conversation. Here, I show how the residents struggle to introduce new meanings about the state of the aquifer’s water quality. These are meanings that can only be determined through observations spanning several decades.

The scientific experts in the public meeting employed a very brief timeline. The longest period of data collection was two years, the time during which water level fluctuations were recorded in a monitoring well by Dave Logan. He argued against using the notion of temporality, opting instead for the notion of a timeless, average (representative) water quality. Randall Burstead (from the CHR) described the aquifer as cyclically changing with the seasons, and noted that the two data sets made by his organization and Logan represented two snapshots in time. Neither of them presented any additional longitudinal data about the aquifer.

Residents, however, provide detailed histories, some of them spanning over thirty years, of the aquifer:

I acquired my property on Dry Point Drive and it had a perfectly good well that had been drilled in 1964. It continued to supply good, clean potable water year round with no reservoir to the new home that I built there in 1971. A year or two after I sold [the property] in 1989, the new owners started to experience both

quality and quantity problems which have progressively become worse over, during the last few years. During 1990 to 1991, I built my new home on the property next door and drilled three wells. Each well functioned for two or three months with questionable quality water and we were obliged to abandon the first two of them. [ST35]

Consistently throughout the meeting, local residents re-framed the water quality problems in terms of decades-long changes: “The amount of water has decreased over the 30 years and the quality has deteriorated” [ST31]. The history of the water quality is an important site of struggle. Whereas the WAC proposes to have a definitive water quality indicator, the residents frame the water quality in terms of a long-term decline of both quantity and quality of the water from the aquifer.

If this claim is taken seriously, and the longitudinal aspect of the water quality is taken into account, then the “snapshots in time” have been successfully re-represented. No longer can the scientific findings about the concentrations of metal elements and pH levels claim to represent average water quality of a static aquifer. They cannot even make solid claims about fluctuations of a changeable aquifer. The scientific findings have to be considered to be part of a larger study that includes local knowledge and therefore become meaningful in the context of the long-term interrelations of humans and the aquifer. The scientific findings, framed in typically monoglossic terms, must then enter into relations with these other stories, stories of wells run dry, stories of water quality and quantity decline documented by people’s changing habits, the abandonment of wells and hiring of consultants. By entering new relations, the unity of the monoglossic discourse is disrupted and scientists must renegotiate the meaning of their cherished words, concepts, and facts in an expanded space of contention.

Once again, the issue becomes more complex, this time as individuals bring their long-term experience into relation with the snapshots in time presented by the advocates of science.

Increasing the Community of Non-Humans

Actor-network theories have made salient the role of non-human actors in human endeavors, their successes and failures. Non-humans play an important role in scientific

discourse, which often makes (the non-human) nature speak and express itself through non-human instruments. An important part of scientific claims of superior knowledge is the access to instrumentation that allows reliable detection of the entities being measured. I see in the following example that the residents recruit their own “instrumentation” in order to justify claims about non-human entities, in this case, contaminants in the water.

According to the water quality analysis performed by the hired hydrogeologist consultant,

The results of our testing [...] show that [...] some aesthetic objectives from the Guidelines for Canadian Drinking Water Quality were exceeded for some of the wells. Aesthetic objectives [refer to] certain parameters in the water [which] may cause the water to be corrosive, deposit forming, or unpalatable. [ST5-6]

The non-humans involved in lab-based water quality analysis had measured the levels of a number of contaminant parameters, such as aluminum, iron and zinc, and had determined that, while the water posed no health problems, there were “aesthetic objectives” that had been exceeded. This judgement is the product of a limited social process: there were a few specialized instruments involved, a limited number of people, and a form of standards from which to compare the numbers produced by the instruments with those which a federal authority has deemed acceptable. When this monoglossic discourse, however, travels to the heteroglot landscape of the public forum, it encounters a different spectrum of non-humans that are rallied to define water quality. The residents may not have access to the reagents and materials needed to define precise levels of indicator ions, but they live in community with non-humans who are in intimate, prolonged daily contact with the water, such as plumbing and dishwashers. These non-humans are taken as valid indicators of water quality:

As to the quality of the water, it is worse than the quantity. We’ve had to replace a new water tank which was new when we moved in [three and a half years ago], and a dishwasher as the corrosiveness eats them away. [ST29]

We tried laying soaker hoses¹⁸ with filters but the water is so full of iron that a filter clogs in a matter of days when it is expected to last months. [ST30]

During the past nine years, I have replaced one well pump, one reservoir pump, two pressure tank pumps, seven water heaters, four sets of swim-spa heating elements, a complete spa filter system, and numerous shut-off valves, taps, and shower heads. All [replacements are] due to the corrosive properties of the water from the well. [ST35]

The above three statements show the recruitment of non-humans to help indicate water quality. In the first statement, the water tank and dishwasher are used as indicators of poor water quality, as measuring entities that can attest to the corrosiveness of the water. The speaker in the second statement uses garden “soaker hoses” to indicate the amount of particulate iron in her water, and the third speaker gives an extensive list of non-humans that all bear witness to the corrosive properties of the water. Through the detailed stories of the fates of the non-humans exposed to the water, the residents layer meaning upon meaning on top of and in contrast to the term “exceeded aesthetic objectives,” which Logan previously used to minimize their concerns. The narratives of the residents, which highlight the arduous and difficult effects that poor water quality has, enrich the “aesthetic objectives” used to connote “no big problem.” The non-humans, with their dramatic plights—“Flowers will burn with the water that we have down there” [ST29], “the stuff stains your clothing” [ST29], “in my 20 years of being a contractor I’ve never seen such disgusting pipes and valves as the ones that came out of my house.” [ST28]—add meanings of damage and distress to everyday life that poor water quality can bring about. Although the non-humans in the labs may indicate that the residents are faced with merely “aesthetic” concerns, the non-humans that actually come in contact with the water are being burned, stained, and corroded.

In this case, “water quality” is being re-represented. The distant, uninvolved non-humans measure the levels of iron, zinc and other elements. The intimately involved,

¹⁸ “Soaker hoses” are garden hoses that are closed at their distal end and perforated with tiny holes. Thus when the water source is turned on, the hose is filled and water begins to leak from the tiny holes, soaking the ground around the hose. This is an efficient way of delivering water to the roots of plants as it avoids water loss due to evaporation and dispersion to non-target areas.

local non-humans measure water quality in terms of encrustation, early retirement, and corrosion. This addition of familiar non-humans, both familiar to the residents and familiar with the water, changes the meaning once again, localizes it, and associates extra cost and ugly dead pipes and machines with the discourse around “poor water quality.” The residents do discursive work to have these non-humans, the ones that matter to them, included in the discussion. In the attempt to expand the community of reporting non-humans; actors from home and garden are added to those of the lab as voices indicating the qualities of the water. This, too, is part of the struggle to bring the conceptualizing discourse of water quality back to their lives, and away from the technical discourse of “aesthetic concerns” employed by the hydrogeologist Dan Logan and by the members of the WAC.

Socializing Knowledge Claims

One of the central aspects of linguistic re-representation is its mocking or derisive nature. By showing that the supposedly rational systematic word of scientific authority is ridiculous, or perhaps enmeshed in compromising social relations, the residents weaken its claim to monolithic direct representation of an objectivized reality. By re-situating scientific claims in the relations that affect or determine them, they loosen the WAC’s grip on the rational method and subsequent claim to financial and political resources.

These people are doing sociology of science to emphasize the relativistic nature of scientific claims, thereby weakening the alliance to truth that the WAC is trying to build. They do this in a number of ways. One is by taking the monoglossic word of authority and re-representing it, tying it to new relations, weakening its claim to being a direct word about an objectivized reality.

Unless you went through a lot of blackberry bushes, which I didn’t really see them disturbed.... [The water] goes through a UV filter and goes out from there to the taps. And I assume [the analyzed sample] was taken from the taps. [ST14]

What we’ve experienced is, rainfall in the order of 522% on average [...] increase over the summer months.... Now, it would seem to me that we’re probably not dealing on an average result

with your tests [...] so that the readings that you're getting are very much diluted. [ST16-17]

In the first instance, the speaker challenges Logan's claim that his samples were all from the aquifer, bypassing any complicating factors introduced from people's plumbing systems. In doing so, he calls Logan's methodology into question, and with it, the legitimacy of Logan's claims to represent the "average" water quality of the aquifer by his findings. The evidence that the resident did not see any disturbance of the blackberry bushes¹⁹ is a significant empirical observation in this community and casts doubt on the legitimacy of Logan's claim to have sampled the wellheads. What water, then, did he sample, if in at least one of his nine instances, he didn't sample water straight from the aquifer? Logan is unable to recall whether or not he braved the blackberry bushes, and this resident's challenge goes without rebuttal.

The second resident—after confirming with Logan that the aquifer is fed by rainwater—challenges the hydrogeologist's claim of reporting "average" water quality by noting that the winter immediately preceding the sampling episode was an extraordinarily wet one. This, the resident contends, must have affected Logan's readings to the point where they could not possibly be considered average.

These two instances are examples of the residents' contextualizing work done in order to re-situate the decontextualized scientific findings presented by Logan within the struggles and compromises that make up scientific practice. It is ironic that the residents use decontextualized authoritarian discourse as a backdrop against these discourses of situated practice in order to argue against the validity of Logan's claims. In other words, they engage in science wars by deconstructing scientific practice, but they need to maintain the "modern" notion of science in order to de-legitimize the social constructivist accounts they create. Although, like STS scholars, they acknowledge the social nature of knowledge, there is still a silent "objective correctness" to which Logan's claims are being held up to and found wanting.

The residents also re-represent scientific claims by invoking new and compromising relationships. These challenge the legitimacy of the actual bodies that

¹⁹ Blackberry bushes present densely tangled very thorny challenges to anyone who would try to navigate them. Anyone's passage would leave traces due to irreversible rearrangement and breaking of branches.

performed the research. Bakhtin hypothesized that laughter emerged from the mocking re-representation of other's speech (Bakhtin, 1981c, p. 50). Laughter is a powerful tool to neutralize claims to authority by those in power. In the following cases, residents situate the municipality and WAC in a humorous or suspicious way, so that they become entangled with potentially compromising relations. Once entangled, these bodies lose their authoritative status.

The third obstruction was the formation of what I consider to be a poorly constructed Water advisory committee. Mr. McGill and Mr. Kitcome [WAC members] had been outspoken opponents of bringing potable water to the people of Dry Point and two others were recruited with the same view. [ST36]

I don't think that if Council was looking at a group of residents that came to them and said we've got \$850,000 and we want to build a park that you would have had near the problems, near the opposition, or near the time spent on making a decision. [ST34]

When Moses was in the desert and needed water, the Lord granted his wish. Moses must be grateful that he did not have to deal with our Mayor and Council. [ST27]

In the first comment, the speaker is suggesting that the WAC had a previously set agenda, and was not at all interested in serving the residents of Dry Point or the better interests of the municipality. A subtle point is that both McGill and Kitcome have Ph.D. degrees, and while residents are quick to articulate the qualifications of those who work for the CHR (none of whom have a Ph.D.), they neglect mentioning the credentials of the Advisory Committee.

The second comment is another subtle personal barb delivered at members of the Advisory Committee and council. The comment derides their "green" political stance and suggests that though they would be quick to save some trees they would not take action to help the suffering residents. In fact, they contribute to the residents' suffering by adding the arduous, antagonistic process of the Advisory Committee's investigations on to the health and security concerns of the residents. The final comment needs no explanation. In the context of the public meeting, the last two statements were funny and brought

laughter from the crowd. Once again, we see the “corrective of laughter”²⁰ being employed by a group that considers itself subjugated to the decisions of a hostile authority.

Once put in the same room as the residents who must live with the decisions proposed by them, the WAC and the technical experts were exposed to the mocking, deriding, and challenging recontextualization of their words and actions. Their study is situated in a more complex context of personal allegiances, methodological slip-ups, and suspect reasoning. The surety of the monoglossic word is now deteriorating amidst a network of other, compromising commitments and methodological uncertainty. The residents’ work helps the science become more meaningful and ultimately more real to the community.

Semantic Challenges

In the above sections, I have outlined some of the heteroglossic work done by the residents. They have worked to introduce different time scales, localities, communities of non-humans and new, previously silenced relations involved in knowledge production into the discourse of a science-based decision about water in their community. This list is far from extensive: I have left out many other elements that they attempted to weave into the discourse, such as economic scenarios and tales of personal hardship. I conclude this section by putting all this work in the context of a struggle over meaning. I find that the meaning of key terms such as “health” or “water main” are hotly contested.

Is health, as the WAC suggests, to be defined by innovative technologies ameliorating the individual well water profiles in a case by case scenario, thus creating sustainable communities and a healthy watershed? Or is health to be defined in the personal sphere, as the ability to bathe in water free of arsenic contamination, or the freedom from anxiety of losing a home to fire because there is no water supply great enough to extinguish it?

²⁰ Bakhtin writes of the “corrective of laughter and criticism to all existing straightforward genres, languages, styles and voices” which “force men to experience beneath these categories a different and contradictory reality that is not otherwise captured in them.” In our case, the corrective of laughter is meant more as laughter used to rearrange established relations, particularly those of power. (Bakhtin, 1986c, p. 59).

Will “water main” come to mean relief to the suffering citizens of Dry Point or the beginning of the end of Oceanside as a rural community, a loss in the ongoing battle between rural communities and encroaching urban development?

This is how I frame the struggle that went on at the public meeting that night, the struggle of the many voices to complexify the network of associations that were handed to them by authority figures, particularly those of the WAC. Health, as defined by the “Guidelines for Canadian Drinking Water Quality,” is reduced to a series of numbers about different elements found in water. The monoglossic talk of the CHR and the WAC focussed only on these determinants.

Residents, through personal stories, layer new meanings, the effects of life with this kind of contaminated water, onto the definition of health. “When we first moved in my teenagers instinctively realized that the water was bad for their bodies and my teenage daughter when she came home she said, ‘Ooh, you know there’s no way that I’m going to bathe in this. It leaves a scale on your skin’” [ST33]. They struggle to modify the meaning of “health” to include their daily experiences and worries. “We were over the acceptable limit of arsenic.... The [consultants’] comments were as follows: ‘Arsenic: continuous ingestion of high amounts is toxic.’ [...] These are not comforting thoughts as you step into the shower” [ST30].

If residents can successfully realign the meaning of health, if they can demonstrate that there is a health concern, then they might be able to align this redefined expression with their final goal: a water main serving their community.

We cannot put a dollar figure on our improved health, the enjoyment of our homes and gardens, reduced fear of forest fire, and the freedom not to worry about the next drop of water.... Let’s get behind our neighbors and recognize their need. [ST27]

Residents even work to appropriate the environmental definition of health, asserting that a pipeline would be good for the local creek, which like the residents, suffers from low water levels during the summer months.

It’s my understanding that the Henderson Creek water is supplied from [...] the aquifer and that during the summer months 50% of the water that flows into Henderson Creek comes from the aquifer.

If we take people off the aquifer and put them on a water main we will be supporting more water in that creek. [ST39-40]

This is a complex statement, as it is uttered in dialogue with WAC members, three of whom initiated a creek and watershed restoration project that has been very active in the community for the past three years. In this case, the resident appropriates the concerns of those members who oppose the pipeline. He speaks directly to them, using the scientific facts established by WAC-sponsored research and uses these facts to argue against the WAC claim that a water main will reduce the ecological health of the region. He uses the WAC members' own concerns to oppose their concerns. The aquifer just became more complicated as the ecology of the creek has now been brought to bear in favor of the residents' arguments.

In this heteroglossic expansion and complexification of meaning, the socially limited terms used by scientists and their representatives find themselves appropriated by two sides in struggle to build new, different networks of meaning. This is a struggle between people who want to garner resources for two very different purposes. One group intends to instigate an innovative, cost effective strategy for individual water treatment. The second wants to begin the building of a water main construction to mitigate the problems that they now experience, and anticipate may get worse. Thus, different semantic hybrids are constructed in this struggle and different associations are made of non-humans, time, and experience with scientific facts in order to bring about a compelling narrative that persuades the municipality to approve the desired course of action.

Conclusion

Familiarization of the world through laughter and popular speech is an extremely important and indispensable step in making possible free, scientifically knowable and artistically realistic creativity in European civilization. (Bakhtin, 1986b, p. 23)

This case study shows that science does not parachute into a community without having to change. In the community, it is not the sole force that defines the essential elements of the problem and paves the way for a clear solution. Science, when practiced and absorbed into this community, is tightly constrained by available resources and is

subject to re-representation by involved, concerned participants. I rallied evidence to articulate the “damned mob’s tendency to discuss and disobey.” In the convoluted discussion at the public meeting, the meaning of water quality, health, and other key terms is constantly being recreated and re-situated as people struggle to place the science within different discourses.

Is this science being misappropriated? Is this irrelevant? Is this an instance of a case where the boundaries between science and other elements of life are blurred to the peril of clarity? “No!” I respond along with Latour, Bakhtin, and others. Alan Irwin and his colleagues described the resulting hybridization process as that of science dissolving into the concerns of everyday life (Irwin, Dale, & Smith, 1996, p. 52). I consider this process of science dissolving into the community as a creative one, one that is necessary for the entry and uptake of scientifically articulated issues into the locality in which they are attempting to be inserted. This complexification is problematic and it is confusing, but it is also what it means to openly confront the different points of view and different life experiences within a community.

In this case, science does not enter into a dialogue with a community—that is too laden with “other-ness” and narratives of delocalized authority. It becomes part of the dialogue, becomes overgrown by it, absorbed into struggles that it quickly becomes subservient to, as residents and authorities struggle over meanings, locations, and justifications for spending money and allocating personnel. Science, tossed around by a disorderly mob re-representing, mocking, laughing, and haranguing with and at it becomes just a part of an expanded context, one of the essential, but essentially contested strands in struggles over, in this case, very essential concerns about how to live a life.

Chapter 11: “Of Traversals and Hybrid Spaces: Science in the Community”

This piece was written in the spring of 2001, the final research paper of my Ph.D. program. It was submitted to the journal “Mind, Culture and Activity,” which is a journal originating from the Laboratory of Comparative Human Cognition at UCSD, a stronghold of American social cultural approaches to cognition. The readership consists of scholars who are interested in the socially mediated nature of cognition. This piece was written for a theoretically sophisticated audience interested in articles that explore the mutually supporting relations between mind, culture, and activity.

The question explored in this paper is one that had intrigued me from early on in my fieldwork—the ability of this organization to get so many things done with so few resources. I articulated this problem in the following way: how did the activists come to know, or enact knowledgeable doings (such as technical projects) with so little technical expertise in their organization?

This is a familiar sub-theme of the dissertation. It appears in the chapter “Ditch and Drain,” where the process of creating a technical event usually carried out by professional consultants is laid out in detail. It also appears in the chapter “Remapping the Landscape,” where the relations involved in acquiring the information and tools necessary to complete a scientific analysis of an emergency in the field articulate the distributed nature of how things get done. But in this final chapter, the big picture of the organization is examined, and a theoretical stance is elaborated that allows a novel articulation about the knowing of the activists. Lemke’s (2001) new elaboration of the term “traversal” is adapted to allow the unit of analysis to be the arrangements between entities that allow for knowledgeable doings to emerge.

The data analyzed here are taken from a variety of sources. I interviewed the coordinator of the Henderson Creek Watershed Restoration Group for an hour and a half. Together, we detailed all the different people and organizations that had supported the Project in its activities up to that point in time. The interview was videotaped and during it a diagram was drawn, writing down names and making associations as the talk progressed. The information in this interview is the basis for this final piece. My

embodied experience as a researcher and organizer for the group, supported by my field notes formed the bulk of the other data that supported this article.

Thematic Issues

Using “traversal” as a unit of analysis, all the major themes in the dissertation come together. A traversal is an instantiation of literate activity. It is the acting out and simultaneous learning of scientific literacy. Representations are generated by work that often involves traversals. These representations themselves participate in traversals, as they travel across many different boundaries in the community. Hybrid representations are also once again a topic of exposition. In this case, their hybridity is related to the multiple boundary crossing enacted in the course of traversing.

Since traversals are a way to talk about clusters of relationships, relation is implicit in the notion. And finally, traversals in this setting are democratic science doings: they are enacted by empowered citizens. One can imagine situations, for example, with citizens’ groups requesting information about newly approved genetically modified organisms, where traversals become blocked by intellectual property legislation. In that case, democratic science could be said to have been thwarted.

By bringing the themes together under a single word, the theoretical journey and struggle of this dissertation comes to an end. Under the notion of “traversals,” the complex relations make sense and seem obvious. Science’s relation to building community is also made more commonsensical. The distributed, fluid, community-building activity of investigating and speaking for the scientifically defined parameters of a watershed is united under one term.

Of Traversals and Hybrid Spaces: Science in the Community

Introduction

There is a rich literature that examines how knowledgeable doings¹ are enacted in the practice of the everyday life within organizations (Henderson, 1995; Hutchins, 1995a; Lave & Wenger, 1991; Scribner, 1984; Suchman, 2000a, 2000b; Vaughan, 1999; Wenger, 1998). These studies document the important interplay between material artifacts, humans, inscriptions, communications systems, power relations, and architecture of work. Science studies elucidate similar interactions in the production of scientific knowledge (Latour, 1999b; Pickering, 1995).

In this paper, I expand the existing discourse by focusing on a type of organization that is markedly different from others studied and is becoming increasingly important in our society: community-based non-governmental organizations (NGOs). These organizations mediate scientific work at the level of local, often rural communities. NGOs work to create healthier streams and watersheds, to map habitat according to multiple uses and values, and to promote environmentally sustainable economic development.

Many NGOs, certainly the smaller ones involved in stream restoration work, present a worksite where fluidity is the norm. Their memberships, cash flow, activities, and active relationships change (often unpredictably) on a very rapid time scale. They can look very different on a year-to-year or even season-to-season basis. During the course of my research, this heterogeneous, fluid nature of the organization struck me as a defining and unique characteristic of the NGO at the core of our study. I became interested in articulating how these fluid organizations learned, came to know and enacted scientific practice. In this article, I discuss three interrelated features of their knowledgeable activity:

1. The highly distributed nature of the centers and relationships in which knowledge or knowledge production was enacted;

¹ I use the phrase “knowledgeable doings” to emphasize that “knowledge” is always a performance judged as such by the appropriate community of practice (Garfinkel & Sacks, 1969).

2. The importance of “traversals,” that is, the phenomenon of traversing both institutional and occupational boundaries as different people and non-humans are recruited to carry out an activity, and the movement over and interrogation of the landscape that is an integral part of knowledge producing activity; and
3. The new community (or communities) that emerge(s) as a result of the engagement of people, tools, artifacts and the landscape.

In carrying out their knowledge-based activity, NGO workers need to abandon the hegemonic stance so typical of science-based political projects. They have no power to write policy or enforce by-laws. They must make their science-based concerns relevant and salient to those they ask for help, thereby enlisting their cooperation. The groups are forced, by the circumstances of their disempowerment, to enact a democratic science, one that seeks to disappear (Irwin, Dale, & Smith, 1996) into the daily concerns of citizens’ lives. I note that this type of situation yields hybrid scientific discourse (Gutierrez, 1999; Lee & Roth, 2001), one where both formal scientific practice and local knowledge combine to create knowledgeable doings. Although they have a government-mandated, scientifically described mission, this hybrid space allows opportunities for NGOs to appropriate hegemonic discourse and practice to oppose the status quo (Bakhtin, 1981a; Gutierrez et al., 1999; Lee & Roth, 2001b).

The traversal of traditional institutional boundaries can have a significant impact on the role of scientific practice in the community. They can localize it and create more highly articulated relationships between people, the landscape, and the history of both. If, as Latour (1999b) suggests, the purpose of science is to socialize a greater number of non-humans into the collective, then I add that new communities of humans are also created in the process of developing these denser networks of articulations.

How do these activists come to know in a complex milieu? How do they manage to act to accomplish tasks, and in the larger picture, construct themselves as an organization within the community? These questions demand a way of articulating a world whose nature continuously changes as agents move into new contexts. Throughout this article, I articulate their knowing in terms of traversals, hybrid spaces and emergent networks.

Knowledge as Activity

Knowledge is something people do rather than an entity in people's heads (Garfinkel, 1996). It is associated with the interactions between people and their lifeworlds, the environment as it appears to them. Knowledge is recognized and acknowledged by the community in which the interaction is situated (Garfinkel & Sacks, 1969; Potter & Wetherell, 1987). Mind, culture, and activity are therefore irremediably intertwined and separating these entities leads to abstractions that are no longer meaningful (Goodwin, 1995; Hutchins, 1995a; Lave, 1988). In this paper "knowledge practices" refer to patterned activities—such as creek monitoring and generating inscriptions—that become part of a publicly acknowledged knowledgeable discourse. Filing documents, accessing databases, and engaging in discussions about what to do to competently finish a certain task are also "knowledge practices." They are social:material² events involving the manipulation of representations of phenomena to affect the future engagement with those phenomena. The databases, file folders, and discussions are integral part of the "memory" or "remembering practices" of a grassroots NGO (Bowker, 1997; Latour, 1990; Middleton, 1997).

Activity theory and situated cognition have a similar interest in the process of the changing nature of engagement in activity outside the laboratory confines of traditional psychological studies (Lave, 1988). Nonetheless, researchers in these domains often pick as their research subjects people who are in relatively stable worksites contained within large buildings—workers in a dairy (Scribner, 1984), insurance claims processing clerks (Wenger, 1998) or hospital workers (Engeström, Brown, Engeström, & Koistinen, 1990). The businesses that hire these people and the institutional routines and resources that structure their ongoing activity are stable and self-contained entities relative to the context of our NGO workers. In the case of grassroots NGOs, where there are constantly shifting relations, contexts, and alliances, a different means of articulating knowledgeable activity, one that can follow the dispersion and movement of the practitioners, is needed.

² I choose this way of expressing the co-constitutive nature of the social and material worlds because I feel the close juxtaposition in the term "social:material" to be resonant with their non-differentiated nature at the research site.

Community as a “Patchwork” Entity

Recent work in science studies pointed out the need to use non-unitary, fluid or patchwork ontologies as lenses for studying social phenomena (de Laet & Mol, 2000; Law and Mol, 1995; Mol and Law, 1994).³ Pertaining to our research, I do not take the creek, the activity-determining object of our NGO, as a unitary entity, described in various ways by different people. Rather, it is a different entity in the context of a different activity (de Laet & Mol, 2000). We come to know a creek in the context of different communities as we come to know the different social:material arrangements that crystallize around it. This “patchwork ontology” (Law & Mol, 1995), which underpins my notion of community and organization, also emphasizes the reflexive nature of writing research. Social:material arrangements are products of a particular research activity and the local links and connections articulated may or may not add up to a unified big picture. We are therefore left with a landscape of “partial and varied connections between sites, situations and stories” (Law & Mol, 1995, p. 290).

This framework, which makes salient the fluid, transitory, and patchwork-like character of activity, constitutes a useful sociology extending the heuristic of situated cognition. As workers in situated cognition have shown (Goodwin, 1995; Hutchins, 1995a), activity such as reading a map can be many things simultaneously—a specific type of perception, a computation mediated by physical relations, and an enacting of culturally embedded narratives of objectified gaze and colonialization (Hutchins, 1995a). As noted in the two studies mentioned above⁴, people and events can be connected through time and space in non-contiguous manners through the mediation of technologies of communication and the practices of remembering. A ship’s position in space, for example, is a “patchwork” of partially connected relations between the outside world, those who sense the outside world through the mediation of historically constructed tools (sailor on watch, using a “perolus” to determine relation of ship to landmark), the

³ Theoretical discourses specify concepts that name objects and events. These determine what researchers are looking for. The discourse therefore specifies an ontology, an ensemble of objects and events that can be found in the world.

⁴ Goodwin (1995) detailed how remote detection systems allowed researchers to see objects below the hull of their vessel and Hutchins (1995) elaborated how telephone communication allowed people to navigate a ship although those doing the navigation could not see the landmarks they were using to determine their bearings.

representations they communicate to those who act on the ships' position (verbal accounts of agreed upon landmarks and their current bearings), and the action taken as a result of the navigators interaction with those representations and their own set of tools (the helmsmen steering the ship as a result of the plotter's triangulation of the ship's position on a nautical map) (Hutchins, 1995a, chap. 4). A "patchwork" ontology extends these arguments to a coherent sociological statement about how things are.

Thus, a pile of boulders placed strategically in a stream is both solid materially, but is also mutable as the structure formed is easily disassembled, either by "natural" forces such as a swollen winter creek flowing at 500 times the volume of the summer flow, or "social" ones, such as well-intentioned high school students who think someone has dumped a pile of boulders in the creek. Its continuity therefore depends not only on its material durability to strong winter stream flows, but also to the social work of discursively constructing it as a scientifically warranted structure that is contributing to community health (Lee & Roth, 2001b). A "patchwork" or fluid ontology is a useful theoretical discourse in this situation because it embraces both the solidity and mutability of social:material relations characteristic of our NGO.

This article is an outcome of my engagement with the Henderson Creek Watershed Restoration Project, a local NGO attempting to "preserve and enhance" the watershed for both ecological and human use, for present and for future generations (Henderson Creek Project, 1998).

The Project as Network

The Project is not just a political actor among others participating in a community where it establishes a network: the Project is the outcome of a network. In fact, "the Project" is a way of talking about the patterns of activity and material objects that emerge from the various linked activities of those who claim membership or association with it. Thus the agencies and individuals in the network do not merely "support" the Project; their participation constitutes the Project. Table 1 shows some of the individual and institutional associations the Project is involved in and the activities in which they engage; it articulates the discontinuous, extended relational network constituting the Project. Figure 1 shows the spatial distribution of these relationships and activities across

the community. In this section, I articulate some of this relational network that constitutes the Project.

There are departments of the federal, provincial and municipal governments supporting the activists in numerous ways (Table 1). Granting agencies, as policy arms of the government, provide money to pay for materials, help, and the coordinator. These are under a number of different auspices, some relating to stream and watershed health (Urban Salmon Habitat Program), some to fish habitat restoration (South Island Aquatic Stewards Society), some to “Eco-Action” (Federal Ministry of the Environment), and some to human development (Human Resources and Development Canada).

The activists write grant proposals for very specific projects, with promised deliverables, such as a fence built along the creek-side trail to prevent people and dogs from disrupting the vegetation on the bank of the creek, or the development of a water budget that models water flow through the watershed. These project-focused grants give very little money for administrative staff or overhead. Thus the money the activists receive shapes the “patchwork” activity of the group. It is rare for a watershed group to develop and systematically work toward achieving a streamlined “strategic plan” or develop elaborate information processing systems such as bureaucracies and other forms of “institutional remembering” of their own (Bowker, 1997; Hutchins, 1995a). To be effective, members must become adept at knowing how to access others’ information processing systems, how to piggyback themselves onto others’ memories and working practices of knowledge production and retrieval. Thus the memory of the Henderson Creek Watershed Project is fragmented, not particular to their project, and is located at different sites. For example, to access past records of stream flow, they must be able to access and use the records (external memory) of the Ministry of the Environment, which has the raw data from the flow meter stored and the computer program that can compile it.

Table 1. (next page) This table lists some of the institutions, groups, and businesses that support the Henderson Creek Project. This table is based on an interview between Stuart and Meaghan, May 2000. Details added through Stuart's experience with the Project.

Institution/Organization	Type of Support	Activities supported	Location
Regional government	Staff, equipment, opportunities to submit samples to their labs	Sediment and bacteriological water quality analysis (some sampling and all analysis performed by Regional gov't staff, sites selected by or in consultation with Project coordinator) Constructing narratives about water quality, developing 'campaigns' based on the results	Creek bed and storm sewer outlets throughout the watershed.
First Nations Band	Volnteer laobur; vision	Process to begin considering a committed group of citizens dedicated to enhancing the water in the watershed Clean up of and access to beach on Reserve Land	Henderson bight, where it drains into the ocean
Community College	Volunteer labour, funding info, "expert in training" personnel	Grant applications for funding for Co-Op student Supplying Co-op student who was capable with computer analysis of data	N/A
University	Volunteer labour, access to expert personnel and equipment, info about funding opp's	Stream surveying, watershed storm water monitoring, GIS mapping, general help (Lee), analysis of GIS data	N/A
Smelly's High School	Volunteer labour, space and legitimized position in which to tell "watershed narrative"	Sediment monitoring, invertebrate monitoring, community mapping	Creek near Godfrey's farm, creek and watershed in general

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Institution/Organization	Type of Support	Activities supported	Location
Municipality - council	Permission; legitimation	Creek Restoration in municipal park; future partnering on water quality projects	Community Park; municipal hall
Municipality – parks staff	Equipment, labour, materials, storage space,	Fence building, trail re-routing	Community Park
Federal Government - Environment Canada	Project grant money	Stewardship project; fence and trail building **	Community Park, individuals throughout watershed
Federal government - HRDC, SSHRC	Funding for personnel	Stream surveying, general volunteering (Lee)	Stream course throughout watershed
FsRBC - SIASS	Grant money	Start up money – pay for coordinator,***	N/A
Private Donors	Funding for personnel	“top-up” personnel funding grants	N/A
Provincial government - MELP	Expert personnel and equipment	Consultation, software**, data to help analyze water stuff – similar in creating GIS map of watershed – supervision/training of student	Office in Victoria
Marine Research Centre	Office space, computing facilities, equipment (including vehicle), office support, state-of the art banner printing	Daily administration, a place to locate the Project HQ, stream surveying, stream restoration, creation of printed material, public outreach, telecommunications, etc. Legitimation by association	Research Institute in rural area just north of watershed.

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The granting agencies that fund the majority of stream restoration work are also policy arms of the government. They have a surveillance system (regular reports, field officers) to ensure compliance as well as a disciplinary system (withdrawal of future funding, or not paying the second half of an allotment). Because these agencies give out most of the funds for stream work based on promises of concrete deliverables and they have ways of checking for compliance, their mandates, to which the groups try to make themselves fit, play a large part in the structural characteristics and activities of these NGOs. These groups can, therefore, be considered to be, among other things, policy instruments of the federal and provincial governments. However, the group needs the participation of multiple members in the community to complete their promised activities, and they often have their own organizational mandates that conflict with those of the granting agencies. Thus, as we shall see, their relationships to mandated policy and hegemonic science are not straightforward

The federal and provincial governments support the activists in other ways. Their office is housed in the federal Ocean Sciences Research Institute (OSR) and supported with high-speed computers, access to lab space for water quality analysis, an unlimited supply of printer paper, photocopying, and color printing access to specialized equipment such as chart-sized color printers (for posters) and scanners and other high-priced infrastructure that the Project otherwise could not afford. The provincial government staff interact with people as they do specific projects and support them. For example, during the preparation of a GIS map of impervious surfaces of the watershed, much of the work was done off-site in the offices of the Ministry of the Environment water quality branch, under the supervision of one of their staff members. The regional government sporadically offers opportunities for the activists to have their water quality concerns articulated through sophisticated lab analyses. It allowed the activists to specify sites for sediment sampling, and tested the sediment samples for organic pollutants as well as heavy metals. Recently, they offered the Project the opportunity to assess 200 storm-water samples for fecal coliform contamination.⁵ Since the size of the watershed is only

⁵ “Storm water” is run-off from storm drains or ditches after a storm event. In rural areas, this is the time that manure piles, spills from industrial areas and faulty septic systems are especially likely to contribute to water pollution. “Fecal coliforms” are a group of bacteria whose presence in water is taken to indicate that the water is contaminated with sewage.

1800 hectares (7 square miles), it was feasible for Meaghan to sample every major ditch and outlet in the watershed.

The municipal government has supported the activists by allowing them access to work sites and legitimating them in the press. The municipal government also supports the activists against political assaults by those local people who do not value their work, and supports the physical work of creek restoration with help from the work crews and the donation of storage space for materials. Currently, the Project and the municipal government are planning a joint grant application to study the feasibility of recycling used water through the municipality to help supply the irrigation needs of the farmers, who currently deplete groundwater resources and the stream through the summer.

Through project-specific funds, technical help, site access and office infrastructure, government agencies shape the activities of the Henderson Creek Project. Thus much of its scientific work is co-extensive with government priorities and activities about sampling and articulating the environment. The Project depends on their funds and sites in order to enact much of their work. Fences built, streams surveyed, and signs erected are all part of the convergence of government policy and the Project members' activity. Much of the Project's activity is aligned with government policy and its science-based environmental mandates.

A number of grant programs have paid partial salary for summer student staff, leaving the Project with the difficult task of finding the "top-up" funds. Partially through her acquaintances at the OSR, Meaghan solicits private donors to help these grants translate into student bodies walking the watershed and measuring it. Though their money helps employ students, the private donors have no say in what the students do, their participation in the Project is only to pay for activity which has already been planned to be carried out.

Educational institutions typically participate in three main activities with the Project. They provide forums for the Project members to introduce ecological discourse about the creek into the community. They provide students who can often enact expert practice (usually through relations with their instructors). Finally, they provide access to tools and other non-humans that shape the Project's knowledgeable activity.

Research work done in collaboration with schools has been an important part of the Project's activities. The projects ranged from a grade-five class painting yellow fish next to storm drains (while learning about storm drains and to where they drained) to a middle school student completing a science fair project that compared fecal coliform contamination upstream and downstream of a chicken farm and high school students measuring sediment load at different sites in the creek. Post-secondary institutions also provide students who help the Project in its work of articulation. For example, a fourth-year geography student conducted a directed study in GIS, environmental studies students did in-depth water quality analyses along different stream reaches, and an education student completes a Ph.D. on the use of science in the project. These students, especially at the post-secondary level, do expert-level work and have the associated networks of relations to support them in this work, thus allowing the Project to know of and speak about the watershed in ways it couldn't have done without them. Through their presence along the creek's length, the Project also extends its spatial presence in the watershed.

Businesses consistently support the project with supplies and help with heavy machinery. During work on the habitat restoration of Henderson Creek, a local arborist donated trees and the transportation of them to use to shore up an eroding sandy bank, and a farmer, though he sold the group the logs, donated the transport of the load to the creek. This transportation, if not donated, could easily cost the project several hundred dollars. Another local heavy machinery shop donated the use of a small ATV (all-terrain vehicle) along with the time of an operator to help with stream restoration work for a day. Nurseries, lumberyards, and others sold their goods to the Project at cost, leading to savings of the order of several thousand dollars. Thus the business community could be said to shape the Project's activities. Although this community is not sought out for help in research and analysis, its members participate, from consultants donating time, to farm machinery businesses donating equipment, in bringing change to the landscape.

Although not listed in Table 1, many residents of the community also participate, as steering committee members, watershed stewards, volunteer fence-builders and so on. Clearly then, "the Project" if defined as the activity and collective of people and non-humans performing the activity, must include this broad range of actors, fading in and out

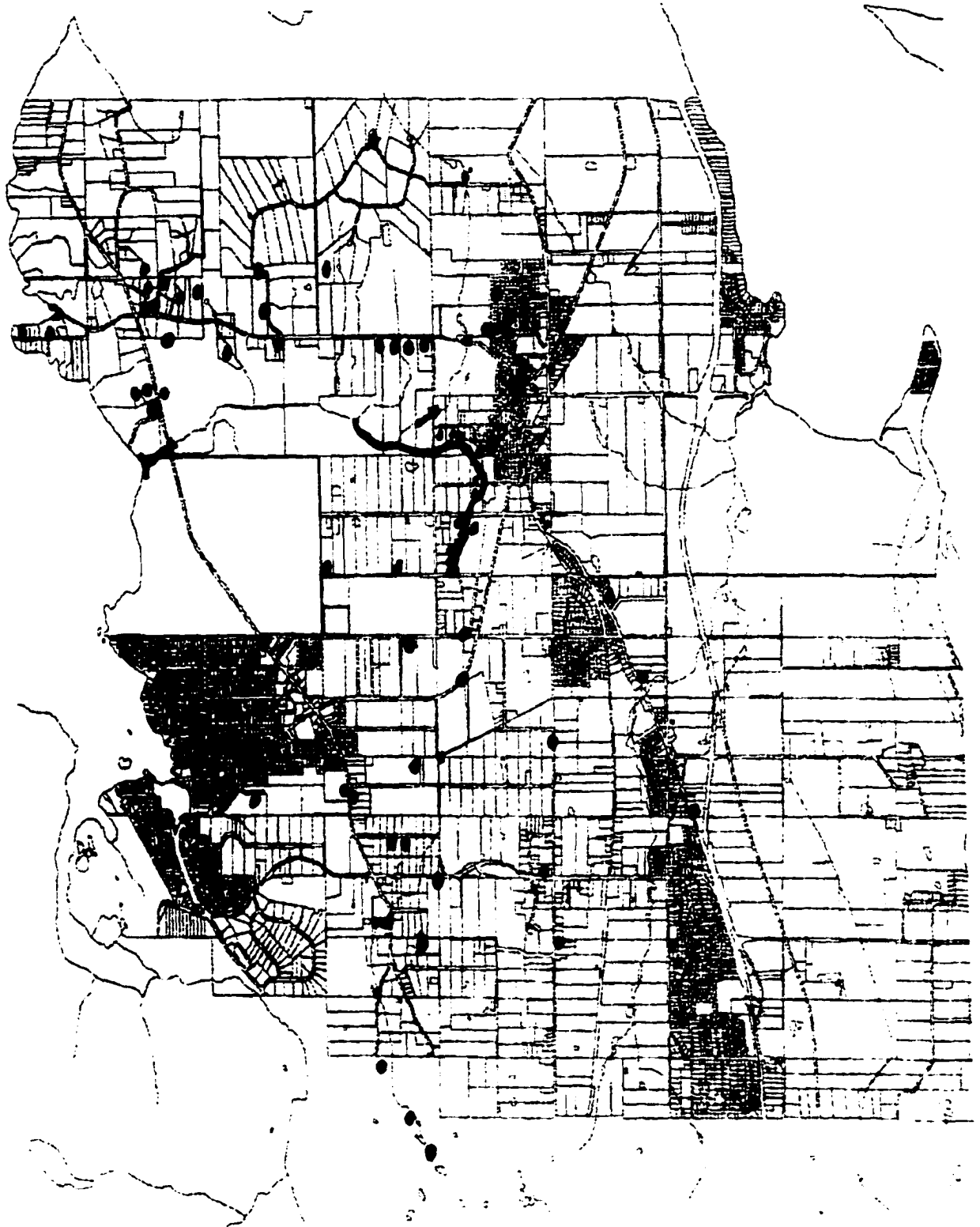
of prominence with the focus of the Project's activity, but all necessary for its ongoing existence.

Figure 1 (next page) indicates those places where the Project is located within the municipality of Oceanside. Each dot indicates a site of Project activity. A site could be the residence of a steward or committee member, the location of a school where the Project has interacted with students, or a business that helped the Project through a donation. The site could also be a stretch of the creek that has been articulated by the Project, either as a site of a one-off surveying event, stream restoration work or continuous flow or water quality monitoring.⁶ This map underscores that the Project is not really located in any one specific place. It is dispersed across the community: sometimes it is found in physical structures such as roadside "cutthroat trout habitat" signs and sometimes it is found in projects that people have initiated in their backyards in aid of the creek.

To know, to act knowledgeably or enact knowledge-making processes, the Project members must be able to traverse this landscape. They must be able to move across it and interrogate it, to determine how the water is flowing, where it is flowing, how clean it is and so on. The Project has and works to maintain access to nearly 30 abandoned wells, five storm-event-monitoring sites along the creek, two flow monitor sites, and a 600-meter stretch within a municipal park where they do restoration and maintenance work. These are non-contiguous sites that are networked through the movements of the activists, who compile and translate records as they visit these sites and interact with the water and the non-humans that are in place to measure, inscribe and affect the stream. These interactions and the mobile inscriptions the Project members carry away from them allow the project members to speak and write the authoritative story of the creek in the watershed. This story can travel and liberate resources in government and business sites far removed from the Henderson Creek watershed. They are also used to tell stories to community groups, interested individuals walking their dogs in the park and school children on Earth Day.

⁶ The sites of many of its institutional supporters are not located in the municipality, so are not indicated on the map.

Figure 1. (next page) This is a map of locations in which the Project's activity has had significant influence. Each dot represents a locus of activity that has supported the Project. Included in these dots are the homes of steering committee members and significant volunteers, groundwater monitoring sites, water quality and quantity measurement stations, the municipal hall, homes of watershed stewards, schools at which the Project has given presentations or otherwise participated in teaching, locations of some supporting businesses, lengths of creek which have been surveyed, etc. This map is meant to be representative, but not exhaustive. As such, it has underrepresented the extent to which the project has insinuated itself into the community.



What do we see when we take a look at the dispersed sites that constitute the Henderson Creek Project? We see government policy, public money, school science projects, water monitoring stations, district water quality analyses, community members in their homes and in local stores, local corporations, municipal government, logs placed strategically in streams, social science research grants, newspapers, students and courses in all types of educational institutions, and so on. There is not just one person or one group that makes the Project. There are many relations that, in their association, give rise to what we know as “the Project.” Yet we do not see all of these relations at once, or all people and groups converging in a single place. Rather, there are local and temporal, situated gatherings, where the activities of watershed restoration are played out in a variety of ways. When I consider such a spatially and relationally dispersed Project, I come to ask questions such as “How do Project members manage this heterogeneity?” and “How do they manage to accomplish all that needs to be accomplished in the face of this extremely fluid and uncertain structure?” I grapple with these questions in the following section.

Traversals

In the previous section, I articulated the diversity of social and geographical locations that constitute the NGO as collection of relational entities. In the following section, I describe how in the daily activities of a grassroots NGO, work is accomplished through coordinated movements and activity between and among these locations. I show that the activists cross institutional and geographic boundaries that separate these dispersed elements in ways that enable the orchestration of the different actants’ cooperation. This orchestration results in the activists being able to enact competent technical performances. I follow Lemke (2001) in calling these movements “traversals”:

Traversals are temporal-experiential linkings, sequences, and catenations of meaningful elements that deliberately or accidentally, but radically, cross genre boundaries. A traversal is a traversal *across* standardized genres, themes, types, practices, or activities that nevertheless creates at least an ephemeral or idiosyncratic meaning for its human participants, and represents at least a temporarily functional connection or relationship among all its constituent processes and their (human or nonhuman) participants (i.e. *actants*). (Lemke, 2001, p .3)

The metaphor of traversals enables me to articulate a *movement across* (meaningful ephemeral arrangement of) actants whose institutional or political commitments would not usually bring them together. I notice that the activists enact multiple traversals both across institutional and geographical distances to achieve their goals.

For traversals to exist, there must be boundaries to traverse. In this paper, I consider “boundaries” to be a convenient heuristic to designate difference. In my work, these differences are often enacted through use of different specialized language registers associated with a shared activity (“speech genres,” see Bakhtin, 1986), shared knowledge of tools, shared familiarity with people, shared relationships with authority or employers etc. Difference is felt by those who are “Others” as a confusion or disorientation about how to act, what to foreground, how to speak in this new situation. Common boundaries articulated by the Project in their talk include those that create and demarcate various entities. These entities include municipal worker/councilor, provincial government department, federal marine research center, First Nations people, old-style farmer, new-style farmer, long-time resident, “old family,” schools, horse community, ecologically-interested community, activists, developers, and “general public” (seen as not knowing about and having no opinion about water issues). These boundaries have both geographical and social character. For example, a member of an “old family” is likely to know political information that few others do and control a sizeable property in the municipality. As enacted, the boundaries affect who can know what not only by restricting who will tell who what, but also, in the case of the activists’ attempts to survey the creek along its length, who can go where. There are farmers who will not grant the activists permission to traverse their land to get to the creek and sample its water. There, the creek is unknown and unarticulated. Designating and traversing boundaries is a large part of the Project members’ work.

The “water budget” is an example of the necessity of traversals to the Projects’ enacting of expert knowledge. The creation of a water budget is a long-term goal of the Project. It will result in a computer model of water flow through the watershed and an estimate of how suburban development would affect that water flow. Such highly technical doings are normally the providence of well-funded agencies’ longitudinal

studies. These are often carried out by staff local to a “center of calculation” (Latour, 1990), where they have access to analytical and computational tools. In order to enact such an activity, the Project, which has none of the highly trained staff nor computational resources, traverses multiple boundaries.

I focus our description of water budget development on three of its aspects: creek-flow and storm-event monitoring, and developing a GIS map of the watershed’s impervious surfaces. Karen, an environmental technician, does the creek-flow monitoring at provincial and federal flow meter stations. To achieve her goals, Karen had to persuade provincial and federal officials to access these stations and get the information she needed. She also persuaded the officials to provide her access to records that had previously been kept solely for archival purposes.

Sasha Reynolds, a local university student finishing her geography degree, made a GIS map of the impervious surfaces in the watershed as a directed studies course project (Reynolds, 1999). Sasha’s GIS work and Karen’s flow monitoring work were applied to a storm-water-event-monitoring project, where the degree of run-off from storm events would be calculated. The changes in the flow of the creek after storm events at different sites could be correlated to the known amount of imperviousness in the catchment basin that fed that part of the creek. This correlation would allow a determination of the extent to which the water flow had been altered by the roofs and sidewalks on the land over which the water traveled to reach the creek.

To enact the project described above multiple institutional boundaries were crossed. Karen’s employment was the result of an agreement between a farmer, who was interested in maximizing the sustainable amount of water that he could draw from the creek, and the Project. Normally environmentalists and farmers are two groups of people considered to be at odds with each other. By being employed by both parties, Karen enacted a traversal between two very different communities of practice. Her movement into the ministry of environment, seeking access to the flow meter and help with data collection, was another traversal into yet third community with its standardized speech genres and practices. There, she came to know John Simons. Interacting with her, he became aware of the Henderson Creek Project. As an employee of both the provincial government and the local university, he was able to direct Sasha, a fourth-year university

student, to the Henderson Creek Project. Through John Simons's participation in the ministry of the environment, Sasha was able to come to know and work with Fred Fernfeld. Fred was an employee of the provincial government, a member of the municipality of Oceanside's Environmental Advisory Committee, and a competent GIS practitioner in the process of compiling a municipality a GIS based resource atlas. He helped her work by mentoring her and providing other relevant "layers" of her GIS map. From her participation with the university, ministry, and municipality she was able to compile a GIS map.

I adopt the unit of the "traversal" to begin to be able to articulate the practices that the activists engage in as they enact scientific work relevant to their locality. This unit is useful in this type of situation because it is the unit that allows me to talk sensibly about the patchwork arrangement of people, places and things that are involved in their work. There is no single institution responsible for the GIS map, there was no site where it was developed, there was no one individual or singular source for the data, there was no singular individual who did all the work. Sasha, as student/volunteer/apprentice/activist/contractor, does not even have a unitary identity. In terms of modernist notions of institutional identities and affiliations, the map is a "mish-mash," an anomaly. Yet I observe that this is how many grassroots NGOs enact science. Traversals allow me to talk as the activist do, of the patchwork relations and movements they must coordinate in order to come to know.⁷ They work across boundaries, aligning themselves simultaneously with portions of many institutions' mandates.

Thus Project members come to know not by controlling resources, but by aligning them, traversing them, flowing and peripherally participating with them as part of already ongoing activities. For example, from the Project coordinator's perspective, Fred Fernfeld was already making a GIS map of Oceanside for his contract with the municipality. Sasha Reynolds was already going to university and participating in a directed studies course. Karen was already measuring water flows in the creek. The

⁷ Grannott's unit of analysis, the "ensemble" is also relevant here (Grannott, 1998). In adopting a traversal, I expand the ensemble, a community of shifting membership arranged around a singular activity, to explicitly include sociological and geographical entities, as well as individuals. I also expand the unit of analysis to include shifting populations of non-humans and the movement or orchestration between sites/groups as important in the development of ensembles.

coordinator worked to align these people together to bring about the creation of a useful scientific artifact, a water budget. Project members participate in scientifically knowledgeable practice through connecting activities, which are each in themselves only partially related to the Project's. They do this through coordinating the members' movements and participation between other actants and localities, creating an emergent phenomenon that is suited to the Project. A traversal becomes a necessary way of coming to know because the Project does not have the resources to enact knowledge on its own.

This example also shows how the Project arises in and as dispersed knowledgeable activity. Knowing about the water flow is not only dispersed across the various well monitoring, flow monitoring and water quality sites that are tested throughout the watershed, but also across different centers of calculation, whose members often must be persuaded to lend their support to help enact a specific project. In the case of the water budget, Sasha and Karen's mobility is also crucial. They cross not only many different social worlds but also move across the landscape to access a diversity of centers of interrogation (monitoring sites) and calculation (university, ministry). They traverse the landscape, their movement enabling a never-before-enacted linkage of different sites, an arrangement, an engagement that allows a new material thing, a map, a report, to emerge.

This traversal is ephemeral, the relationships that brought it into being are not codified, or defined by contract or fiat. They emerge through the movement, activity, and unfolding of a project, and, as people move on, they disappear (although on differing time scales). In this case, Karen has moved on to new training as conflict resolutions specialist, Oceanside Farm is no longer a sponsor of the group or maintains its water monitoring activities (though the project supports Karen in monitoring ten of the original 30 wells (personal communication, May, 2000)). Sasha has moved to a different part of the country to pursue a Master's degree, and Fred Fernfeld has retired from the Ministry. The Project had no resources to stabilize any of these relationships beyond a few months. But they do have a GIS impervious surfaces map and some preliminary data to help model water flow. They are now waiting for more money to continue on with the work.

What kind of knowledgeable performances do these traversals generate? I provide an example from a later stage of the development of the GIS map. Once she had

developed a GIS model of the impervious surface coverage of the watershed, Sasha presented it to the Project's steering committee. Though the committee members had no technical training in GIS, they insisted that she alter some of her imperviousness assignments. In one case a steering committee member exclaimed "I've been through that field in January and it's got six inches of mud. There's no way that it is 75% impervious"⁸. In response, she changed her "percent impervious" designation of that piece of land⁹. The committee required that she "ground truth" her model and confirm her designations¹⁰ before they would be confident enough to allow Meaghan to present the map to council.

In this example we observe a new hybrid knowledge emerging, as local knowledge comes to frame and inform formal knowledge (Gutierrez et al., 1999). In the instance of Sasha and the steering committee we see a student bringing an officially sanctioned representation developed in the company of university professors and professional GIS practitioners to a steering committee. The committee members altered the representation because it did not resonate with their embodied experience of the locality it represented. It does not matter to them that most geographers consider playing fields to be 75% impervious, they know that there is an abundance of water in the soil when it rains because they walk across the field. In this example, as in many others witnessed throughout our fieldwork, scientific representations and practice are significantly affected by the influences of untutored, non-scientific community members.

The mutability of the scientific representations does not mean that the new representation lowers scientific standards, but is instead a legitimate outcome of the engagement of a new hybrid community of practice (Lee & Roth, in press). In this community, scientific discourse and representations are influenced directly by local knowledge and political purpose. The artifacts produced are situationally appropriate in and for the community where they must function. It may not be acceptable to an academic community of scientists, but in this case, they do not have the disciplinary

⁸ From field notes of steering committee meeting, Jan 7, 2000

⁹ From video tape of presentation at OSR, April 4, 2000.

¹⁰ Her original imperviousness designations had been based on reading maps of land use in the municipality and then applying appropriate standard ratings of imperviousness to those regions based on their land-use zoning.

powers they do in other instances, nor are their concerns necessarily relevant. And, as became evident during the steering committee meeting, practices acceptable to the scientific community were not sufficiently sensitive to be good enough for people who had embodied familiarity with the landscape. The local residents resisted the scientific representations that did not accurately reflect their experience of being in that place. Happily, unlike other situations chronicled (Wynne, 1996; Lee & Roth, 2001c), in this situation the citizenry whose place was being represented had the ability to alter the representations so that the representations matched their experience. Gutierrez et al. (1999) speak of a “third space” in between official and informal discourse, a space of hybrid talk. To them, this is a space of empowerment, where the local and informal is not denigrated in favor of the formal. I suggest that the outcome of these traversals, this new hybrid “community science,” also is a new genre, appropriate to the boundary crossings that create it.

This hybrid space also allows the group, while ostensibly enacting official government policy objectives, to enact resistance to dominant narratives. For example, the GIS map is part of a collection of artifacts and tools that the Project plans to use in order to make further development in the municipality problematic. In any one granting agency, university course, or ministry, there is no mandate for stifling land development. Most governments are pro-development. But by combining different legitimate aspects of educational institutions’, ministries’ and granting agencies’ mandates through a traversal that involves them all partially supporting an ostensibly scientific activity undertaken by a university student, the Project has used science in a way that could resist status quo policies. Traversals and the hybrid spaces that result from a non-hegemonic relationship between scientific practitioners, residents and Project members can be a site where paradoxically effective resistance is mounted to other governmentally supported projects.

In this section, I have described a number of aspects of a unit of analysis called the traversal. I find it useful to articulate the fluid, dynamic and dispersed nature of knowledgeable activity undertaken by grassroots organizations. In an ontology that eschews a single unitary order and instead embraces a host of partially connected “patchwork” realities, this notion allows me to articulate what knowing may entail. It allows me to speak sensibly of the hybrid discourse, the hybrid knowledge I encounter in

the field. And it helps me account for how an NGO with such strong institutional ties can engage those institutions' resources to counter the status quo that they usually support. In the following section, I explore what happens when traversals become more stable through time.

Emergent Communities

Knowledgeable doings create communities of actants. In this case, a new community whose relations go beyond merely knowing a creek. Through the tracing of familiar traversals, new relationships emerge, new people become connected, and a new organization comes about. This section is about the transformation of traversals for the sake of knowing into a network or community.¹¹

Over the course of the study, I noticed that familiar traverses emerged through the Project's activities. As they become more durable, traverses become part of what I consider to be a community network. For example, as a result of prior engagement with the Project, people were talked about as "on-side" and were frequently consulted for help in their particular area of expertise. Landowners who gave the Project permission to traverse their land were solicited to become more deeply involved as stewards. Certain friendly councilors were repeatedly contacted as part of the Project's dealings with the municipality. Through the activity in which they have engaged and engaged others in, the Project begins to build a community made of actants¹² who have participated in the work of articulating the watershed. The activity that people have performed led them to know each other, to remember, to be interested and able in new areas. This is almost entirely a community based on shared discourse and concerns, and localized to the region in which they operate.

As traversals, or parts thereof, become a more routine part of the activists' lives, they then become starting points for new traversals, new arrangements. The network constituting the project grows larger, reproducing through new relations springing from its current ones. The municipality has recently requested the Henderson Creek Project's

¹¹ Moreira (2000) also discusses the transformations that fluid entities undergo as they stabilize into networks.

¹² Although I do not emphasize their role here, the Project comes to know and be familiar with a multitude of non-humans as well as humans.

participation in a scheme to study the feasibility of using recycled water for irrigation. Community members, previously engaged in conflict with the Project over stream access, now approach them seeking intellectual “ammunition” in their fight to oppose a proposed development. They are sure that the new development will adversely affect the creek, and that this can be used to their benefit. Bureaucrats in the Ministry of Agriculture force local farmers seeking to deepen their ditches to first work with the Project and come up with a solution to their flooding fields that satisfies both groups before they will grant them permits. The traversals have left traces.

The community (of practice, and the municipality) itself becomes more articulated as more people in it come to know each other and engage in practices, such as volunteering to do water quality monitoring, that result in their knowing more about the landscape. By attempting to change the landscape, people come to know how their governance system works, and conversely bureaucrats become aware of the landscape of previously unremarkable areas.¹³ By increasing the connectedness of the residents in a community and by bringing the creek into the activity systems of the bureaucracy and the bureaucracy into the activity systems that interact with the creek, scientific practice and scientific language contribute to the growth and emergence of new communities.

By participating and gaining embodied experience of the practices and discourse of science, people experience more than the technical words suggest (Lee & Roth, 2001a). Embodied experience, instant recognition, feelings toward each other, the emotion of discovery of what a creek is, are all beyond the purvey of the forms handed out by the bureaucratically organized granting agencies. In situations where science is used as a means to an end that the group agrees is morally good, scientific practice can indeed support the emergence of communities of resistance to the status quo. Groups of people become involved in activities that change the practices of a municipality to support a society whose living is less damaging to the other beings co-existing with them.

¹³ “I also know that there’s been some attitudes as well changed at the ministry of the Environment who described that creek. I mean the main guy who’s involved with stream protection called it a ditch and when he saw this community group kind of take it on and collect some funding and get some community involvement and he’s kind of changed his attitude too” (Interview, Karen C, p.6).

Enacting Knowledge in a Fluid Organization

I return to the original question: How does a grassroots organization come to know and enact expert knowledge? I do not have a simple answer. Instead, I have described some recurring patterns that became salient in the course of my research. The first is that a grassroots organization can not and does not attempt to collect all the necessary information and tools it needs at one location, which it then controls. It does not even attempt to own them. Instead, its computers and databases, instruments and scholarly papers are spread across the region, in separate, largely independent centers of calculation. Similarly, a watershed (its object of knowing) is not a singular entity, but has different features and problems in different regions throughout its area. The activists acknowledge and work within this highly de-localized world.

The activists enact their knowing through traversing the landscape (institutional and physical), arranging, aligning, negotiating, and entering into relation with the different parts such that they get accomplished what they need. To know, they must be able to move. They have no access to means of legitimized violence to discipline others into doing what they want them to. Instead they must be able to translate their concerns into those of whomever they want to have help them, and be willing and able to help them in return. This cooperative situation leads to hybrid discourse, where scientific terminology and artifacts co-exist alongside local “non-scientific” ones.

Finally, the traversals sometimes stabilize disparate entities into familiar networks. Such networks exist in the form of water monitoring stations at five points along the creek’s length. To monitor them requires friendly landowners, who instantly recognize and smile at the Project embodied in Sasha’s visits for measuring the volume of water flowing after a rainstorm event. It may be a number to call in the ministry, a person who can help them get an urgent sample analyzed for free, when the cost of commercial analysis would be prohibitive. Or it could be a university co-op program coordinator who informs the Project coordinator of available corporate funding with which to hire summer students. These traversals across community networks become the project, become a new community of people and non-humans, all talking with and knowing about the watershed.

Finally, this movement, orchestra or ensemble of individuals cannot be considered outside of their historically constituted goal. For them, to know is to know enough to help the environment,¹⁴ to know is to include others so that they too can know and help the environment. To know is to begin a movement to resist the separation of people from place, to begin to resist the silence that our landscapes have had since the European colonization, and to begin to live in an area that is more, and along with it, where we are also more.

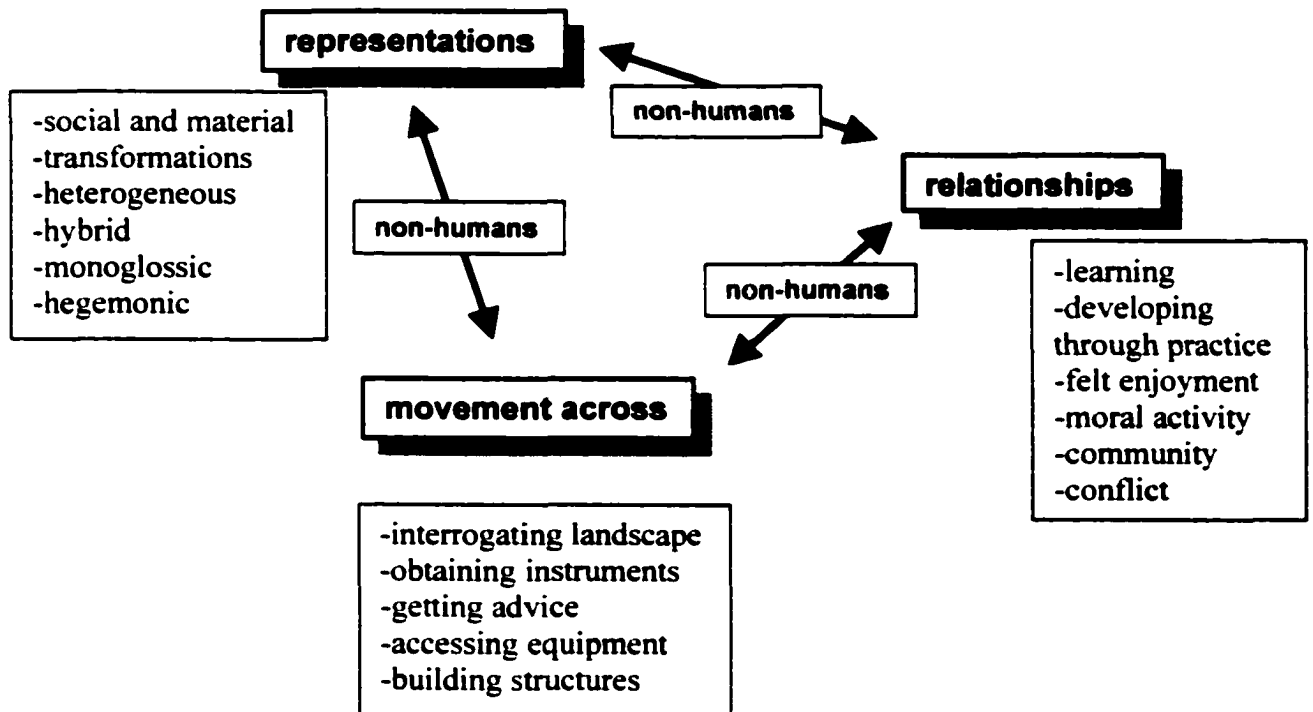
¹⁴ Here, I acknowledge that “the environment” is not a naturalized entity in itself, but is a word commonly used to designate the sum total of biophysical processes of which we are aware, and of which we are a part. In practice, it is always a particular part of the environment that we deal with. It just sounds good in this context.

Chapter 12: Conclusions

Building on the theoretical work in traversals, the major themes covered in the dissertation are framed within an interactive schematic. We thus return to the original purpose of the research, which was to investigate and describe science as enacted by a grass-roots environmentalist group.

Taking the lead from recent work by Roth (Roth & Lee, 2001), scientific literacy is treated as a property we ascribe to certain types of activity, work that is recognized as scientifically literate. In the “Traversals” chapter, the elements of scientifically literate activity as enacted in this case study were laid out. In the figure below, I present the elements diagrammatically. In text boxes, I outline some of the features of these elements that have been worked through in the six chapters.

Scientifically – Literate Activity at the Community Scale Typically Involves



Each shadowed box is a feature abstracted from the notion of “traversal” as developed in the “Traversals” chapter. The arrows indicate mutual co-determination. That means that, for example, representations are both dependent on and foster relationships.

The purpose of including non-humans within each set of arrows was to indicate that all the movements, representations, and relationships are dependent on the participation of non-humans. There would be no ground water model without automobiles, well logs, and computers. The relationships formed between volunteers would not happen without the creek, without the tools mediating their activity and without the ability to communicate across geographic space. Next to the box which names each of the elements is a text box that lists some of the different stories told about that element through the dissertation. The purpose of the text boxes is to refer the reader to aspects that have been elaborated throughout the text of the dissertation.

According to the schematic, scientifically literate doings in the community are the outcome of the interaction of movement, relationship and representations, all mediated by appropriate non-humans. Through the course of the dissertation, the heterogeneous, fluid and hybrid nature of the representations have been elucidated. Their importance as providing occasions for activity together, as well as being dependent on relationship for their formation and circulation is shown many times. Movement was also described as crucial. Activists needed to move across the landscape to collect supplies, to test the water and generate data, to build, meet and survey. Their movement was crucial to their participation in events such as the Open House, and therefore crucial to the formation of relationships and the circulation of representations.

This literacy is framed by the fourth theme documented in this dissertation – a democratic participation in governance. This final theme gives the activity its flavour, its purpose. It is the reason why the landscape is interrogated, is the purpose for the proliferation of representations. In a parallel story line, it is also the reason for this dissertation, to develop a way to articulate the legitimate achievements of a group seeking to use scientific practice to influence local governance and resource management policies.

**Chapter 13: Becoming/Belonging:
An Account of Learning how to do Qualitative Research during
Graduate School from a “Legitimate Peripheral Participation”
Perspective**

This final analytic chapter is outside the subject area covered in the other six chapters. It is a reflexive chapter, taking up a theme proposed by the committee at my committee meeting: exploring the dual nature of my legitimate peripheral participation. During graduate work, my activity was that of a dual nature. I was participating in two communities of practice, that of academic researchers and that of grass-roots activists. The deeply enmeshed, reciprocal nature of my participation within the two communities seemed to my committee a fruitful phenomenon worth exploring. This chapter is my exploration of this theme.

The chapter will be submitted for publication in the on-line journal, Forum Qualitative Research (FQS). This journal is a project, supported by the German government, whose purpose is to serve as a major portal into issues about the conducting of qualitative research. It is bilingual, English and German, with a few articles also appearing in Spanish. I thought that because this paper explored the experience of becoming a qualitative researcher, it would be a fitting candidate for publication.

The on-line publication format has influenced the structure of the paper. In the html version of the article, there are pop-up windows linked by hyperlinks scattered through the ongoing narrative. These windows contain e-mails, reports, field notes and other “raw data” from my graduate studies. In this, the paper version, these windows appear as boxed text. The purpose of using this approach was to allow the raw data, which may tell more than the polished analysis, to have a voice in the text. I wanted to use the medium to introduce an increased richness into the narrative.

Thematic Issues

This text takes up the thematic issue of transformation and applies it to a personal project, my learning and experience of being a graduate student. The narrative is

grounded in practice theory. Drawing from its Marxist roots, practice theory is well suited to discuss the mutually transforming struggle that is involved in the practice of cultural reproduction. I take advantage of this theoretical ability to write about my learning and struggles, my becoming and belonging through the activity of researching and writing with Michael.

The concept of “legitimate peripheral participation” is explored in detail. I write about the experience of participating in overlapping communities of practice, and what that meant to me, what it felt like.

Finally, it is a personal essay, and insists on the co-presence of feelings and objectivity, on passion and knowledge, and on the transformative potential of the struggles between two people engaged in the practice of academic writing and research.

**Becoming/Belonging:
An Account of Learning how to do Qualitative Research during
Graduate School from a “Legitimate Peripheral Participation”
Perspective**

Learning to Be, while Becoming someone else, and who do you Belong to?

Learning is to become someone, to belong somewhere or differently where we already are. My graduate studies did not attempt to prepare me for any life anywhere else, rather I immediately became involved in the practices of qualitative research as performed by my supervisor and his other graduate students. After two months I was urged to begin writing my first paper for publication. Nothing I did ended up in the dead-end of a course instructor’s pile of marking for the term. Instead, I presented at conferences, wrote articles for publication and worked in the community. My training plunged me into legitimate practices of academic qualitative researchers.

But that was not the only world in which I was becoming and belonging. My research project involved me participating with a local grass-roots environmental group. I did research through becoming a useful member of the group. I volunteered in almost all of their activities and acted as personal assistant to the leader. Near the end of my term, I was competent enough in their practices to take over as interim leader while the coordinator needed to be away for a week.

I was engaged in a double world of learning, of becoming. An activist, a researcher, a researcher while being an activist. This paper explores how this double learning to be, an enculturation into different cultures, played itself out through the course of my graduate studies. Throughout, the notions of learning, researching, and identity will be interwoven to explicate a research and a type of research training that is personal, engaging and productive in a way recognized by the research community.

This text includes many windows, in which correspondence or “raw” field notes are presented. Through the layering and contrasting of the voices in the windows a set of conversations, between actors caught in the heat of the moment, emerge. The intertwined,

multilayered nature of this particular program of graduate studies is reflected in the structure of the article. This article is designed to be contrapuntal. Different modules of first person narrative, field notes, correspondence and theoretical arguments are played off against each other in a manner in which their correspondences and conflicts become important. I intend for the reader to make meaning just as much through noticing or reflecting on the relations between the sections as the on arguments articulated within the sections.

The first section of this paper outlines some of the main features of the particular kind of LPP training I participated in. I present both post-hoc descriptive and analytic text, as well as samples of correspondence between Michael and I that provides a second conversation, that of individuals caught within the action, into the narrative. The second part of the paper explores a meeting of theoretical and personal, as I tell stories about bridging the two worlds and how an LPP style graduate training played itself out as struggles between supervisor and graduate student. Struggle is conceptualized as transformative rather than just destructive. Finally, I argue that this involved, personal style of graduate training on research is part of a methodologically sound and valid research training.

Section 1: “Legitimate Peripheral Participation”

“Legitimate peripheral participation” (LPP) is a particular articulation of learning within a broader tradition of research and theorizing in education, the “social historical” view of learning. The term “legitimate peripheral participation” refers to a way of understanding learning that explicitly acknowledges that people are always involved in social settings, and their learning can be best regarded as changing participation in these settings rather than passively absorbing and processing information presented to them (Lave & Wenger, 1991). Two major strands of these thinkers are the practice theorists, such as Bourdieu (1991) and Eisenhart (1998) and those who study “situated cognition,” that is, theorizing about the learning that goes on as people interact with their communities of practice and non-human environments (Brown et al., 1989; Chaiklin & Lave, 1993; Kirschner & Whitson, 1997; Lave, 1988; Rogoff & Lave, 1984). What unites these two strands of authors is the insistence that learning must be theorized in terms of

an individual always in relation to their physical and social environment. They frequently study people as they work through everyday cognitive tasks, such as deciding what product is the best value at the supermarket (Lave, 1988) or learning to ski (Burton et al., 1984). They try to appreciate the contributions of the world outside the body, including tools and other artifacts to individual cognition. Thus their research methods are often ethnographic, using participant observation (Lave, 1988) or video analysis methods (Jordan & Henderson, 1995).

Four points about this analytical framework are salient to understanding it in the context of this paper.

i) Learning is always embedded in the social – this does not imply that all learning is group activity, but acknowledges that we can never escape being embedded in material, social relations. Even activities such as reading, which may appear to be solitary, are deeply social. The means of production and distribution of the book, the ability to read script, the house and chair are all socially determined entities, depending on resources available, money (socially agreed exchange), taste, and so on. The implication of this argument for education is that we must always take into account where learning is taking place, and what its role in the ongoing means of social production and reproduction is in that particular time and at that particular place. It also implies that learning of knowledgeable skills is subsumed by the learner's experience of participating in a community of practice.

ii) "Legitimate Participation" suggests that the learner's participation is a legitimate contribution to the respective community of practice. This contrasts with educators' claims that they are preparing potential participants in some community of practice by having them participate in activities (such as doing lab experiments whose results have been known for years) that have little relationship to the work-sites and communities where microbiology, for example, is done. From the perspective of LPP, the activities of such students are legitimate practices in reproducing the culture of educational institutions, and work must then be done to make the practices they engage in at school relevant to workplaces for which they are ostensibly being prepared. Through an LPP perspective, people learn what they do, in relation to the socially mediated situation that they find themselves in.

iii) “Peripheral” is a term meant to convey that the learner’s participation is part of a network or community of practitioners and thus is a part of a collective effort. Peripheral is not meant to indicate that a beginner has a more peripheral position relative to an old-timer who is more central. Rather, it points us toward a unit of analysis where all members’ participation is legitimate and peripheral to (or always a just part of) the ongoing functioning of the whole. People, as they become more “expert” (recognized as such by a particular community of practice), become more fully engaged in the goings-on in a community, become more entangled in the relations that constitute its activity. Thus, the direction of learning in an LPP model is toward full participation. This implies not just a mastery of a set of skills, but a belonging in a community, an ability to participate in more and more of its practices (which includes knowing what is appropriate to talk about in the hallway, and what is more relevant to the coffee room). This way of articulating learning seeks to de-center mastery and domination of others or situations in favor of a description that focuses on an increasing entanglement in the relations that constitute a community of practice.

iv) “Community of Practice” refers to “a set of relations among persons, activity and the world” that determine the activity system in which an individual participates (Lave & Wenger, 1991, p. 98). These relations are between entities, both human and non-human and include relations such as rules, division of labour, production and consumption. A “community of practice” also includes the settings, such as buildings and locations, as these are often socially meaningful aspects of the practice. A novice’s trajectory toward full participation is determined by their participation in, acceptance by and recognition of this community.

...And My Experience of Graduate School

In this section, six aspects of my graduate training (which was oriented explicitly toward a practice-based notion of learning) are outlined. This is to illustrate how a type of education explicitly modeled on a social-material notion of learning was played out. We make no pretensions about saying that this is how it should be done. Nor are we claiming that we are the only ones who have done it this way. By telling our story, both personal and theoretical, we hope to engage the reader. Do you see yourself or your graduate

student in these stories? What is your stance toward them? This text seeks to bring out questions and opinions and perhaps inspire experiments, rather than to prescribe anything.

Normally, graduate students at this university take courses for the first two years of their training, writing essays and doing directed readings dictated by professors, then embark on a limited research project which they think up, carry out and fund, then finally write a thesis for a committee. This was not part of my experience. Rather, I embarked on doctoral studies with a professor publicly states on his web site that:

“University faculty members’ responsibility in supervision is to enculturate graduate students into a community of practice.”-
(Roth, 2001)

The unstated implication of this quotation is that graduate students are enculturated into a community of practice of academic researchers, not of graduate students. In my training, there were no reading lists, no term papers whose network was only a professor and myself. So that was the first distinguishing aspect of my trajectory through an LPP – it was not a journey into a community of people becoming graduate students, but that of a graduate student becoming, belonging to a community of academic qualitative researchers. In the following section, six aspects of this training are discussed: immediate engagement in research practices, scaffolding, the role of theoretical discourse, a negotiated, emergent research project, taking care of practical details and continuing the cycle.

Learning through immediate engagement in a community of researchers.

Our version of graduate studies involved my immediate participation in the research projects underway in Michael’s research group. Before my registration as a graduate student was complete, I was beginning to do the work of a qualitative researcher.

At 01:09 PM 7/14/98:

Stuart, I can cough up \$900 (+ benefits) for employment this summer. This would go through your regular payment account? Or did you want to be employed as a grad student?

Means you should be doing some productive work. I would suggest maybe after

the meeting tomorrow some interviews and analysis thereof. Contact through Meaghan, maybe starting with her, and getting some of the people in the Henderson Creek projects.
Michael

Since I was being supported by a research grant, it was expected that I would contribute to the team's projects. I began my graduate studies by negotiating and enacting research within Michael's research group.

My research project took shape out of a collective experience – it certainly involved personal introspection, but also developed explicitly through discussions with other graduate students working with Michael, and through the imposed necessity to be working on something since I was on payroll.

09:06 AM 7/13/98

Hi everyone.

I would like to organize a meeting where we do some work together. Although I do not want to push agendas and leave it up to the needs of individual members of the group, I thought we should begin this time with talking about, brain storming, analyzing for the work Stuart is beginning. To this effect, I want to bring a video I recently shot at an outing in which someone who has already restored a stream in one community came to advice members of a different community on what to do, think about, etc. to bring cutthroat back into their stream. It is sort of a design meeting where we can brain storm on what and how to collect as data. where to take it, etc.

Michael

At one of the first meetings where my research project was being discussed, we (Michael, other graduate students, myself) analyzed some video data that had been recently shot. The data had yet to be analyzed and we were taking the first shot at it. It was not a sequence that had already been analyzed, with Michael leading us through the analysis to prove a point. We became immediately involved with meaningful analysis, in the presence of people who were competent at it.

At the meeting, through talking about the footage, comments on methods and ways of data collection were shared between the more experienced graduate students and me, the newcomer. I learned (as I continue to learn) how to look at video footage from a social science perspective, how to frame events, what sort of material is important and so on. Besides learning about video analysis, I also learn about data collection, as when my

turn comes to carry the camera around, I have an idea of what people consider valuable footage. By plunging directly into activity within a community of practice, I learn the myriad of tacit understandings that come with a social situation such as how people take turns in speech, how different grad students frame the same scene and how these framings are accepted by Michael. I learn what it means to do qualitative research with this particular group.

Scaffolding

Before I had officially begun my graduate studies (or collected any data), I had already submitted an abstract for a presentation at a poster session at an international conference to be held in April. Its structure was mapped out for me, so I could write something in an area which I had little theoretical expertise. I include this instruction to point to the importance of scaffolding during my training.

06:40 PM 7/29/98:

Hi Stuart, Mike

I think we should write a proposal so that you can do your first science education conference presentation next year in Boston. Here an outline. It doesn't matter that much of it comes from Mike and My experience, by the time the conference rolls around, we will have done a lot of thinking, data collection and discussion.

LEARNING SCIENCE AND SCIENCE TEACHING AT THE INTERFACE OF DIFFERENT COMMUNITIES

Stuart Lee, Wolff-Michael Roth, G. Michael Bowen

INTRO: From my SSHRC proposal

THEORY: From my SSHRC proposal

Data Collection: From an article I will provide

RESULTS

Some summary

Description of interacting and learning:

1. Use Vignette from SSHRC
2. Use vignette of data analysis and actual graph (scan)
3. Use vignette from our joint venture with First Nations kids

When I come back next week, Thursday or Friday, the three of us should sit together and hammer this out. I am attaching a piece written with Domenico and Nadely which will serve as resource for describing the learning of a preservice teacher in the context. Also a resource for writing the above data collection section. In my absence, Mike can provide a model from last year's proposal for getting this set up.

Let's get cracking....

Michael

I did not listen to anyone lecture on the appropriate format for writing conference proposals, then submit a mock proposal to a class to be marked. Rather, I learned about it through basing my efforts on examples provided by Michael, another experienced grad student. Mike. In this example, there are four resources from which I can draw to use as templates for my proposal. First, the outline presented in the e mail scaffolded the organization of my proposal. From Michael's grant proposal, I learn how he presents the theory I am currently learning, but am not yet an expert in. From an earlier article that employed similar data collection techniques, I learn how what I am doing as a researcher is written about in a way that is acceptable to the community in which I am practicing. And from Mike's earlier successful proposal for the same conference, I learn how things are worded and how arguments are presented in that forum.

Finally, what I produce will be the topic of discussion between Michael, Mike and I. I receive direct feedback on it under circumstances where I can change it in immediate response. Thus I learn through becoming involved in a recursive, legitimate activity supported by two others who are experts in the community I am entering. Note that the examples provided are not meant to force any one way of communicating on me, but as a resource for structuring my contribution. The writing of this proposal is framed as a step in a changing process of learning, where Michael assures me that by the time I will be presenting, I will be much more expert in the discourse than I currently am.

This example demonstrates the main alternative to course work as preparation – scaffolded meaningful participation. This is a major feature of the learning trajectory that social learning theorists emphasize. Whether it be learning to become a tailor (Lave and Wenger, 1991), to navigate a navy vessel (Hutchins, 1995) or become a midwife in a Mayan community (Jordan, 1989), learning is mediated through participation in the presence of people who are already competent at the tasks, and who can give the beginner a job that involves reduced responsibilities within the context of an already functioning system of activity. Bourdieu (1992, p. 222) writes "One can really supervise research only on condition of actually *doing it* along *with* the researcher." Thus the novice learns by appropriating habits (skills with tools, ways of speaking, ways of writing, etc.) which are already working at the site where the novice is engaged (Hutchins, 1995; Lave & Wenger, 1991). Alongside the knowledgeable skill novices learn, they also develop a feel

for how the entirety works, what their skill means in terms of the overall community's goals (Lave & Wenger, 1991). In this example, as in many others during my graduate career, I was led directly into new activity without prior preparation, but with working examples alongside me.

Negotiating the Research Project

Determining a research project is one of the crucial stages of a graduate students' career. Projects are often selected after a year or two of coursework, sometimes (as in many American universities) after a smaller research project has been done. Students are encouraged to take time to consider their research project, ponder over the exact details, and refine the question they are seeking, carefully craft methodology and so forth. This is then presented to the supervisor or a committee for comment or approval.

In contrast, my research project emerged through the tangle of desires, opportunity and the constant push for getting involved in practice (Bourdieu, 1992).

Field Notes, July 10, 1998

It seems that Michael is suggesting that I use the activist experience at hand (ie the henderson creek exercise) as a starting point in my studies. It has a lot of the elements that I am looking for - community involvement, education, environment, science, activism, native relations....As we get to know each other better, I sense he is more and more interested in the activism slant of things or picks up on my interest of the activism slant of things and encourages me. Where do I want this to go?

This is ultimately one of my most passionate topics - science in service - tool for awareness and social good rather than for the imposition of power. Science as an excuse or obfuscation, rather than clarity. The stories science gets embedded in, to rationalize behaviour. Yes, this is my passion.

2:45 PM 7/29/98

Hi Stuart,

...I am not sure whether you thought we are getting involved as ACTIVE participants in the Henderson Creek project. I think it is more passive, and only the school aspect will be more active. I would though, like to document the kind of interactions between different stake holders, and the kind of learning that is going on. Being around Meagan would help you get to know the people.

1. Have you had a chance to "interview" her?
2. What about trying to hit the mayor and principal of Bayside, Wayne Hunter?
3. What about meeting Eddy Cormack who has a connection to the Band?
4. What about you attending a meeting of the water advisory council where McGonicle, Eddy, and others are members?.....

:

INVOLVEMENT

I think it is a good idea to be involved. What you should do is to keep a daily (field) notebook in which you record the kind of things you learned, observed, etc. If we put it together as an html text, we can produce the kind of data bases we have done in the past. Michael and I can introduce you to it, you can take electronic images and put them in, scan materials and documents, even use video clips, etc. In this way, I could stay updated as I read along what you are producing.

I think it is good to get involved, but document both your own learning and that of others.....

:

INVOLVEMENT

As to participation and involvement, try to track down Wynne (I think it is Bryan) about the involvement of the social scientist if s/he is/wants to be rigorous. He not only researches science and the various protagonists but actually gets involved.

Michael

9:09 PM 7/30/98

Michael:

I've been talking with Meagan, and she will come up with projects for me to participate in. she is quite keen on this. some of the topics which have been suggested include:

- read and analyze the Henderson Creek Master Drainage Program. for useful material.
- edit/assemble a report she is preparing which will get wide distribution throughout the community
- compile stream data
- collect steam data
- adapt a procedure she has for determining fecal coliform count so that people with little or no micro training could use it.

Stuart

As is shown by the above email correspondence, our research design emerged through a tripartite dialogue between Meaghan, the coordinator of the activists, Michael, and myself. Our design emerges through the relations of an already involved practitioner (me), through and by my negotiations with those whom I am researching, and for whom I am researching. Thus methods and ethnographic practice could then, following from and through my involvement, be suited to the occasion that I was participating in. No detailed prescriptive work was necessary. Looking back, it would have been impossible to plan out the trajectory of research taken, due partly to the very unpredictable nature of the activist group's activities themselves.

The questions which would organize my research arose as I was participating. Through conversations with Michael about my research, I kept him up-to-date on the activists' doings, and discussed with him what was capturing my attention. Through these discussions, he helped me articulate my observations in theoretical terms, and often would be able to help me find other scholars who were also interested in the topics (such as representation). We would agree on specific research strategies that I could bring to the situation that would help me pursue my interest. Our methodology and our research problem to emerged as and through our engagement with the situation at hand.

I mention this style of research, "emergent design," as part of a piece on legitimate peripheral participation because, although an LPP based graduate studies would imply only that the graduate student do activities similar to others in the community of practice, it was a way of doing research that was amenable to learning as one goes. Because as I progressed along my graduate studies trajectory, my abilities increased, and with them the types of questions I could ask, the design of the research was flexible enough to shift to accommodate my new interests.

Theoretical Discourse

For the most part, I was not part of a class, and did not attend seminars or ongoing discussions in a research group. How then, did I become adept at or learn about the theoretical discourse of my community? I wrote up abstracts, and through conferences, met people who engaged me in much theoretical talk. Discourse came through presenting papers at conferences, meeting other researchers, both students and professors, writing

papers, and participating in research grant-writing activity in the presence of others. Bakhtin (1981) writes about the “appropriation of another’s word” (implying participation in a dialogue) as the root of learning how to speak with others in the same community.

I learned theoretical discourse through practice, not through class-room discussions rooted in the triadic initiation-evaluation-response discourse (Poole, 1994). I learned about articulating issues that were important to me in negotiating my way through the research project or having an article accepted by a journal.

8/2/98

Stuart: I don't see how a psychology [social psychology], replete with calls to all sorts of motivation on the part of acting parties can then just avoid dealing with the notion of the individual...

Michael: The whole thing about social psychology is that it importantly deals with the individual in the society, and that individual actions cannot be understood lest they be considered as aspects of actions in the context of society. Furthermore, when you do some phenomenological readings, you will notice that SELF is only possible because of OTHER, both in physical and intellectual terms. It is because, and beginning with, the recognition of OTHER that we recognize SELF. And both require that we always and already are of the same material, and later of the same social origins as OTHER. Language, concepts, gestures, all these things can be used for individual purposes BECAUSE they make sense in social situations, because they have been negotiated for years and centuries...

In the absence of course work and in the necessity to continue on with research, theoretical discourse was rich and focused on matters at hand. I would e mail more established community members with questions as they presented themselves through my engagement with reading material, the writing of field notes and the experience of the research project. Thus I participated in a theoretical discourse that was tightly related to what I was presently immersed in.

Through attending conferences, I met people with whom I could carry on theoretical discourse at a distance. Through e mails and occasional meetings, we delved into deep aspects of the interpretation of some of the things I was noticing in my research.

3/14/01

The idea that situations, context-rich somewhat typified activity complexes of hums and nonhums, are themselves literate, in the sense that meaningful ongoing activity is mediated by semiotically-functional artifacts, is very interesting. I would develop this along the lines that each situation type, or perhaps each sort of traversal among situations that circulates us through a somewhat invariant space of people, things, etc. (you need a more generalized sort of typicality here), has associated with it (in fact in a case like Meaghan's clearly it is emergent) a unique literacy, a unique language, a sort of sociolect....JL

In the above communication, I learn about theorizing some of my initial observations. Through dialogues with colleagues, including some of the big names in the field, my understanding is enriched. Again, what is talked about is important to me, I participate in an on going dialogue about real theoretical concerns addressed by the community in terms of the particularity of my own research project. Conversely, I discover what is interesting to the community and can adapt my research and writing to these interests (Stengers, 2000). In dialogue, I become exposed to authentic vocabulary, which, through participating, I cannot help but learn. This is demonstrated in the above e mail from a senior colleague, where he employs academic vocabulary in tight juxtaposition to words I had used. This sets up a space of hybrid discourse (Gutierrez, 1999), where my informal or untutored speech isn't dismissed, but is fit into more formal speech, acceptable to the community. Thus my ability to talk about these theoretical notions is scaffolded on my colleague's well developed ability. This creation of hybrid discursive space is argued to be an empowering practice, and considered an excellent learning site (Gutierrez, 1999).

Over the course of her review of the first article we submitted for peer review, this reviewer, a senior practitioner in the community, along with the journal's editor (herself a leading scholar in the field), provided a review with detailed references, including a reading list of twenty-four books or articles that would be relevant reading for what we were writing.

From Anon Reviewer 7/26/00

P1, paragraph 1: The statements quoted are NOT primarily about water as the author(s) state, but are locally situated meanings about the whole watershed in context, viewed through different meanings/readings/interests. The watershed itself is a boundary object in terms of multiple and contested readings. (See Henderson, "The Political Career of a Prototype" 1995 for an account of contested boundary objects; Haraway, "Situated Knowledges" 1991; Lave *Cognition in Practice* 1991; and Suchman 1987 *Plans and Situation Action* on situated meaning/knowledge.

Though I didn't read all of the references, by attending seriously to her comments, I "took a course" on scientific representation and society, while at the same time preparing a paper for publication. This provided me with extensive and deep reading in the subject area of my choice along with the benefit of being able to revise an "essay assignment" that had been handed back with a "mediocre mark" of "revise and resubmit." There were no grades here, but in the end we produced a paper that was good enough for the world's best journal in science and technology studies.¹ Instead of a mark on a confidential transcript of grades, my name would be a part of the community. Scholars the world over would know about my writing and interests. Through publishing in this journal, I would have accrued "cultural capital" meaningful to others with whom I would interact in the future.

Practical details

Graduate students are often responsible only for their own progress through their degree program. In contrast, I researched and purchased a digital video camera, research software, found technical support for transcribing audiotapes, worked with designers who helped construct a database for the project's ethnographic data and so on. These tasks supported my research activity to some extent, but also support the research of others as well. This type of activity familiarized me with how people go about arranging the resources necessary for doing research, and how researchers frame situations in terms of grant proposals. Through taking care of these details normally assigned to professors, I began to learn the habits and practices of academic researchers as they go about carrying out research projects. I learned how research is materially supported and how to research

the commercial world in support of academic research. These are not experiences I could have got by engaging in role playing or writing a mock-grant proposal.

Continuing the cycle

As I become a more fully involved practitioner, I now participate in helping new graduate students and potential collaborators understand what we do for research. I provide both theoretical references and talk with them to help them understand our ethnographic focus of research. In short, I am participating in the reproduction of the community (Wenger, 1998), as I help introduce others into the parts that I can competently enact.

Section 2: Bridging the worlds – Identity through Activity

Struggles

Becoming and belonging are not necessarily easy. Social reproduction, the co-determined “fitting” of one individual into a new community, is a process fraught with struggle (Bourdieu, 1992; Lave & Wenger, 1991). It involves the mutual transformation of both the community and the individual. The novice, wanting to belong, must learn the practices and discourses of the community, but the community, needing to reproduce itself, also must find a place for the novice. By bringing their own uniqueness to a community, the novice also always has the power to transform it even as they are being transformed (Bourdieu, 1992).

This work of belonging is also the work of becoming (Bakhtin, 1981; Wenger, 1998). Identity is something emerging from the struggle between the individual and the community of practice into which they are entering (Wenger, 1998). Identity, socially negotiated, involves different activities in different environments. From this perspective, the individual is seen as the nexus, or site of mixing, of the various activities that they engage in throughout their network of communities (Bakhtin, 1981; Wenger, 1998). Identity is not stable, but is constantly a work in progress.

From this perspective we acknowledge that identity is work, and that this work is often highly personal. Bourdieu (1992) writes of *illusio*¹, a word he introduces to imply that the participants who participate in a community do so because they are interested, because they have stakes both in the community itself, and their place in it. It implies that the participation can sometimes overtake the participants, who sometimes go so far as to risk their lives, to continue in the activity or maintain the status they want to have in the community. Our activity matters to us, we are invested in it, it becomes a passionate undertaking. A felt tension ensues (Lave & Wenger, 1991), and conflicts arise as the novice attempts to balance his interest with the demands of the community. “Identity” is not experienced by an individual as a detached entity, but as a suite of emotions, of passions or interests which play themselves out in their body and experienced community (Gomart & Hennion, 1999).

In my Ph.D. this work of becoming/belonging, and the stakes involved on both sides were often enacted as struggles between myself and Michael. However, our self-conscious awareness that these struggles were part of the process of identity formation allowed us to experience and enact them as transformations. In the following excerpts, three thematic struggles are detailed: expression, balancing multiple identities and doing explicit identity work done in order to fine tune the student supervisor relations. Through these stories, we both explicate the rich entanglement between personal and institutional interests, and how through these struggles, new or transformed bodies of work, or ways of being emerge.

Expression – how to write, who we are

Michael, concerned for my learning and enacting culturally appropriate practices of writing and research, attempted to ensure that my work was in compliance with those expectations. I, on the other hand, came into the degree program with my own historically constructed desires and practices. As noted previously, my graduate program

¹ Illusio...is to be invested, taken in and by the game. To be interested is to accord a given social game that what happens in it matters, that its stakes are important (another word with the same root as interest) and worth pursuing.....Furthermore, this specific interest implied by one's participation in the game differentiates itself according to the position occupied in the game (dominant vs. dominated, orthodox vs. heretic) and with the trajectory that leads each participant to this position. pp116-117

was oriented towards production of publishable material which bore the names of both mentor and student. What was written would be public material and would place both Michael and myself in the community of academic researchers. Both of us had something at stake, and what was written needed to be appropriate to both our own senses of good writing and research. This arrangement set the stage for many struggles over expression.

Importantly, we do not consider this to be a story about “power over,” that is, a supervisor squelching a graduate student’s desire to “write what must be written.” This is rather a story about the tensions and struggles as both people, each in their own way peripheral participants, seek to produce something in a way they consider acceptable to the community. It is a story about two people attempting to come to terms with what they must say to their community amidst concerns of being accepted.

Michael and I co-authored a piece on autobiography as a research tool in science education. It was meant to be a conversational piece. We would both write autobiographical sections, and then follow up by having a theoretical conversation over and about the respective pieces. Michael had initially responded to my autobiographical section as too “flowery.” After I had edited it once to remove superfluous language, he repeated the claim and suggested that I re-write my autobiographical section to be like his.

4/16/1999

Stuart, I had a look at it. I find that your language is a bit too flowery. For example, take a look at the following paragraph:..... I won't be able to sell this. Would you mind going back through your part and write it in such a way that it is passionate, yet reads a bit more like the other parts, a bit on the hermeneutic side. It is not even clear whether you experienced it as this, or whether this is your post hoc objectification.

Cheers, Michael

I received this e mail just before he left for a ten day trip, when e mail contact would be very limited. Through my conversation with another grad student about the situation, a solution to the problem of having to write an autobiography just like your supervisor’s emerged. I would use his e mail as the first comment in our conversation! Because Michael was away and not able to readily communicate, I had time to research my resistance and articulate in terms of feminist theory and “liberation” pedagogy. I

responded to his e mail in a scholarly fashion, pointing out what I thought the problems in his comment were through a critical analysis.

Take a look at your memo to the first draft of my autobiographical account (Figure 1). These are strong comments and a suggestion for action which I think has rich implications....The term "flowery" with its pejorative and dismissive connotations could have been substituted with "emotive" or "descriptive." I see the adjective you chose as an expression of domination. It is also a very macho put-down—calling another man's work feminine and superfluous (Spender, 1980, p.78-81). It reflects the masculine, competitive nature of science (Connell, 1993, 200-201), which is something we work against in creating an inclusive "science for all"(Roth & McGinn, 1998). (Lee & Roth, 2000, p.63) *Research in Science Education*, Vol. 30 (1), p. 63

This exchange set the tone for the whole paper, which emerged as a discussion about power relations in the academic community and these relations' effect on language and expression, the masculine, heroic language tendencies of scientific narratives and the question as to whether science could ever be truly libertarian.

As I think about teaching in terms of cultural reproduction, and reflect on your discipline comments, I now consider an important part of the curriculum its "repressive" aspect. We need to be cautious in our rhetoric, not to promise a utopian vision that does not include the means of social reproduction which have been discussed in this article. If we can't escape them within the constraints of an article, how do we expect to escape them when society confronts a radically different notion of science? (Lee & Roth, 2000, p. 71)

From an education perspective, it was through these times of conflict that I did the most theoretical work. Whether attempting to respond to editor's comments, discovering ways of articulating the emotions or impressions I had about what I was writing, or responding to an intellectual challenge by Michael, I turned intensely to books and to other scholars for help. These conflicts required deep answers to ameliorate. I felt an urgency, a drive, *illusio*, to "win" the game, to be able to express myself in a way that was both intellectually and emotionally satisfying and to be able to withstand the critical eye of the "gatekeeper" of the first "obligatory passage point" (Callon, 1986) to the community I encountered.

This struggle over expression, evident from an early period in my graduate studies, would continue to manifest itself in later efforts.

10/18/00

Hi Stu,...I read the manuscript and was a bit discouraged, a bit a lot... There is so much that is changed, and the coherence we put in does not exist anymore... There is no more theory, you say that we theorize something but we don't.... You have written in the informal style you use when you are talking.... I was sweating, being embarrassed...

My more personal, informal style, a deliberate political and aesthetic choice on my part, often clashed with Michael's preferred "objective" or removed style. In our autobiographical piece, though it was difficult to experience, the way we "played out" the struggle allowed it to surface, to take over from our preconceived notions about what the article was to be. As a result, the work was transformed. Our words, as Bakhtin (1981, p. 340) might say, reacted in a "chemical union," creating something entirely different from what we had planned. All our conflicts over expression have ended in reconciliation, in my finally being able to craft something acceptable to both of us.

01/16/01

Finally, this is a very fine piece. Congratulations.

This example also plainly shows how membership in a community crucially affects the creative activities of its members. As he articulated in his criticism of my autobiographical contribution, Michael experienced a felt need to "sell" the special edition due to the typical practices and standards of acceptability of the rather conservative community of science educators for whom the issue was targeted. My struggle with Michael, then, was not my struggle with just Michael, but also with the scientific community and its way of articulating experience. And it was also an outcome of his struggle with the same community for similar purposes. A "community of practice" perspective allows us to appreciate the complexity of interactions which become manifest through our daily actions.

Legitimate Peripheral Participation, Qualitative Research and "Multiple Marginality"

Because of the research methodology that I enacted, my graduate studies plunged me into a situation where I was simultaneously an apprentice in two different worlds. I was becoming an increasingly full participant in environmental activism and in academic

qualitative research. How was I able to manage my identity while being an activist when I was simultaneously being a researcher of activists?

Star (1991) writes of the experience of “multiple marginality,” where membership in multiple communities leaves one “at once heterogeneous, split apart, multiple... we have experience of a self unified only through action, work and the patchwork of collective biography” (p. 29). She writes of the “high tension zone” of living between accepted communities, of negotiating rival allegiances, of unifying some sort of identity among the many identities we enact in our different communities. Wenger (1998) refers to this work as “reconciliation,” the ongoing effort to bring coherence to a self that, due to its participation and belonging in many different communities of practice, has multiple, sometimes conflicting roles. They both emphasize that self is unified in the moment, through activity. I also experienced the effects of this multiplicity. But what seemed more salient to me throughout my studies was the unity experienced, as Star puts it, through action.

While I was with the watershed group, I was an activist, working with them on whatever problem they had assigned me.

Participating as a Grass-Roots Activist

I prepared speaking aides and spoke to school children and community groups about watershed stewardship.

I helped to prepare hand-out material for public education campaigns (link to some stewardship material).

I participated in field work with school children.

I aided in the construction of in stream structures.

I participated in group-sponsored public events.

I researched archival material and transformed it into inserts within kits given to stewards (thumbnail of aerial photos).

I helped prepare displays.

And participated in many of the mundane chores of activist life, filing, picking up stuff, delivering stuff, scanning, helping in the field, printing brochures, liaising with volunteers and contractors and so on.

When I left the site and began writing field notes at home or talking to Michael, I was a researcher. This seamless activity across the “two worlds” is shown through different documentation I produced in response to a fish kill. One afternoon, as I began doing some routine in-stream volunteer work with another volunteer, I discovered that

there had been a kill-off of trout, the fish the activists were working so hard to create viable habitat for.

From field notes, June 23, 2000

I was about to dump some pea gravel in behind 'my riffle' and I noticed...another white belly.

Jane and I had been discussing what we did two weeks ago when we discovered a big (28.5 cm) trout belly-up at that riffle, we had just looked at it, measured how big it was, and left it there...

So this time I went in the stream to pick it up and while I was down there, I noticed another white belly, and looked a little upstream, and noticed another.

"Jane," I said "I think we're going to change our activity this afternoon. Looks like we've got a fish kill."

Meaghan (the group's coordinator) was away, so I helped to organize an investigation into the incident. As I was helping with the fish kill, I was also doing participant observer research. My actions, though, were seamless across the two different communities because I was familiar enough with each one to know what type of action was appropriate within each community. In e mail correspondence, I write about the "same" incident to two different people, Michael (as my academic supervisor)

6/24/00, 12:31 AM

Hi Michael;

We found a fish kill in the creek today. bad news for the fish, very bad news, but good news for a 'construction of event' piece.

I've written about our work in the attached field notes. The case is so small yet so nice that I think there's potential to do some good work with it.

What do you think?...

I've got the video camera.

Cheers

Stu

and Meaghan, (as the coordinator of the activist group) who have very different concerns.

6/25/00 12:14 PM:

Hi Meaghan;

I've attached the water data. Jane has the stuff from Friday afternoon. If she calls me today, I'll add to the table and send it off to you.

Here's some more numbers:

As of yesterday, we'd pulled 23 trout, between about 13 and 23 cm from the stream over the course of Friday evening and Saturday. On Saturday, I put on hip waders and used a dip net to collect an extensive count. I waded the stream from the culvert at Sprite road until the log jam just past the two felled trees farther up the trail (just before the private property). I was pretty careful in my search and

checked under the surface of duckweed etc that was on the water, so I'm pretty confident that I got everything that was there until that time.
I also pulled out a (dead) stickleback and a crawfish.
there were fry (or small fish at least) throughout the reach.
There was a thick scum on the surface of much of the water, it was not iridescent - this makes me think it's not an oil scum.....
See you soon!
Stu

Later, I write about the experience in my field notes,

From field notes, June 23, 2000
Back at the fish-kill site, we discovered that the dissolved oxygen was very low. John said that in his twenty years of work in this area he had never seen a reading that low. He was very interested in getting an exact count of how many fish had died and in trying to trace the cause of the kill. There was a scum on top of the water. We wondered whether it was possible to trace it back to its source.
We took John to the point where the creek crosses the major roads in the district and we found the block of farmers' fields within which the transition from clear to polluted water occurred. But we were not able to do too much more exploring, as those farmers did not support the Project and did not want people on their land doing research in their ditches...

and the incident was written up as a paper submitted to an academic journal.

As Lee and Jane explored the creek and accessed resources within the community, they participated in multiple educative relations. They dealt with a real problem, improvising their struggle of securing data the extent of which they did not know, and both learned. For example, by the end of the afternoon, Jane knew about water quality analysis, the people who normally do it, where they live, their subjective possibilities, and how to do some of the water analysis herself. Through Lee's knowledge and relations, Jane's participation in and relation to the Project and community changed. She was on her way to becoming a functional Project member not because of a specified curriculum but through her simple participation in the situated activities of community members. This type of learning is called "legitimate peripheral participation." (Lee & Roth, in press b)

Meaghan also wrote an e mail to the entire project membership as well as a newspaper article.

Subject: Fish kill in Gordon Creek

Date: Mon, 26 Jun 2000 14:51

As some of you have heard by now, we had a fish kill in Gordon Creek on the weekend. The count so far is 25 dead trout, however today's survey may see this number increase...

The fish died in the upper end of Community Park from the top of Reach 1 at Sprite Road (for those who know the restoration reaches), south toward Smelts X-Rd. This was the area where the restoration efforts end, and meet the channelized section flowing from the flats.

The fish apparently died from lack of oxygen. They likely started dying on Thursday. 13 were collected on Friday, 10 on Saturday and 2 on Sunday. DO [dissolved oxygen] levels on Friday and Saturday were unbelievably low at < 1.0 mg/l....

I will call the paper and issue a press release once we have done the nutrient analysis and gotten more input/ information...As unfortunate as it is, maybe this is the impetus for a united effort to address conditions through the flats.

These different writings underlie the fact that I am always addressing what I do to someone, a text is always part of some community's discourse (Bakhtin, 1986). Though I appear to be writing different identities for myself: that of scientist, student, researcher, academic author, my felt experience was that of being one person communicating to many others, my identity "unified through action" (Star, 1991, p. 29).

I rarely experienced a conflict of allegiances or identities while involved in my research, unlike other ethnographers (Harris, 1997). Since I was involved in a practice that involved multiplicity, this felt congruency is a phenomenon that requires an explanation (Callon & Law, 1995). My feelings of congruence were helped by three salient aspects of the research situation: a common discourse of activism in both communities, a prior relationship of trust with the coordinator which allowed me to be "just another" volunteer, and the lack of relations between the two research groups.

Both Michael and I consider ourselves activists and both of us identify with the goals of the Henderson Creek group. Thus I did not experience the conflict of doing things while an activist that were at variance with the philosophies and goals of our research team. The method of participant observer research legitimized my deep involvement in the activists' activities, thus my direct participation with the activists was congruent with my role as a researcher. As is apparent from the links above, the text I wrote as an academic author also depended on my engagement with the activists.

My prior relationship with Meaghan, the coordinator of the Henderson Creek group, allowed a non-problematic entry into and joining with the group. Because I was “just Stuart” and not “the researcher from the University” to her, I could form relationships of trust quite quickly with others. I also chose a “non-invasive” research style, which was based much more on recording what I did and what I overheard rather than querying participants with specific research questions. Although my role as a researcher was never completely erased, I behaved as if, and was treated as if I was just another volunteer. For example, in my letter reporting the fish-kill incident to Meaghan, I did not speculate on the “construction of a fish kill,” nor did she wonder how I would use the incident in my theoretical work. Because I did not attempt to bring social science discourse into the activist community, I did not need to make choices about “who” I would be at a research site at any given moment.

The other important factor in the ease of my identity experience was that the two communities of practice were relatively isolated from each other. Thus I did not need to perform mediation or translation work between myself and others who were similarly involved and may have had stakes in certain interpretations or consequences of what I did. This is also apparent from the correspondence shown above, as there is little overlap between what I write about to the different parties. The Henderson Creek group did not take much interest in the results of my research, as it did not become applicable to their undertakings. Thus I did not have to account for my research activities to those on whom I based my research. Similarly, the outcome of my activities with the activists relative to the activists’ goals was of little relevance to Michael. Because of the isolation between the activities of the two communities, it was easy to maintain a separation of activities while also maintaining a congruent identity. I could use one voice and doings while helping the activists, and another while helping Michael, and because I could experience both voices as part of my overall career trajectory, I did not experience identity conflict as I carried out my research.

I experienced the high tension zone much more as I attempted to balance the relevant activities of the two communities into my life (Lave & Wenger, 1991).

Feb 22, 2000 (field notes)

Arrrrgghhhh! What a stupid day. I am having difficulties at the moment. Tired, pouring stimulants - coffee, sugar, into my tired body to keep it going, keep it going. Feeling the strain of having a life where every day, it `s a different project... Feel the stress of being passionate about part of my work and wanting to pour more time and energy into it, but being held back by other parts, by my commitments to others.

And am being divorced from the smug self-satisfaction of "working hard to get things done" by the words of Sasha urging me to "take time to connect." I am also noticing more and more what gets lost as my life speeds up and to me, what gets lost is the time I have to just chat with people. As an ethnographer, this could be a grave methodological error. Not just "just chat" it means that much of my talk is about all the stuff I am doing, how I am suffering, what else I have to do - etc - this must be so Boring to people - I feel boring - So now I`m in a double bind - I feel guilty if I relax and take things more slowly, I feel guilty (somewhat) if I don`.

The field note quoted in the previous sentence shows I experienced tension through limits on my time, and how this spilled over into how I enacted my identity and led me to question my research practices. I was worried that my harried state, brought about by trying to balance the demands of multiple communities of practice – "Feeling the strain of having a life where every day, it `s a different project" – would prevent me from having insightful conversations or deep relationships with others whom I was working with. Besides feeling guilty about not being a valuable friend, I was also concerned that such shallow interaction would then reduce the quality of my research "data."

Identity – Constructed, Emerging

The issue of what I spent my time doing went beyond the issue of what was good research practice, however. This was a high tension zone because I was not participating in graduate studies to belong to a community of academic researchers, but to enter into a different, hybrid community, one I hadn`t defined yet, but one that involved writing, analysis, science and society in a way that affected the practice of those whom I researched and wrote about. As someone on a career trajectory, I felt the need to explore, to expand my understanding of opportunities, and to define myself within society. I could not just follow Michael around to conferences and meet his friends. This was the third major struggle I faced during graduate school: what community was I attempting to enter? Who was I to become? Thus the question of how this graduate program of study/research fit into my historical trajectory and how I would fit myself into some

community's historical trajectory became central (Bourdieu, 1992; Lave & Wenger, 1991). It felt like, and still feels like, a basic survival issue.

Through my relationship with Michael, I felt forced to create myself in writing. I was dependent on funding from Michael for my survival while a grad student. I was not only his graduate student, a novice in social science research and writing, but also the person Michael was depending on to run a legitimate research project and write publications to ensure that he receive continued funding. Thus he had a stake in the style and substance of my writing. He had a stake in how I spent my time, and what my interests were. We were related through both employer/employee relationship and that of student/supervisor; there are different and conflicting aspects to these relationships, especially with respect to how the student/employee spends their time and what they produce. These aspects were not worked out in seminars of self-discovery but rather forged in the heat of ongoing practice, always in the context of participating in research.

Dear Stuart,

I felt quite duped, deceived, and hurt by your proposition not to work on writing, and to delay any further work until the end of April. ...I think that a lot has to do with a confusions or conflation of relations...

It may well be that we can work something out that involves partially collecting further data. But in any case, I would expect that we are clear about our roles. Primarily, I see your role as employee in the construction of a physical database (boundary object). If you do not want to be a co-author (to a certain extent your interest and your time in these activities), then so be it, though I would find that regrettable....As a grad student, if you want to peruse data that you have collected qua employee on my research project, you are expected to make an appropriate request and appropriate acknowledgment of the SSHRC grant under which you have been employed.

We will talk about these and further issues during our meeting on Wednesday. I am asking you to be forthright and open, more explicit about your intentions and specific actions.

It was through this pressurized real-life situation that I was compelled to create myself in text.

Michael: Please help me understand or describe the set up in your own terms so that we can come to an agreement.

Stuart: I frame my primary responsibility as “what do I need to do to enter the community of practice for which I am preparing myself, and for which the federal government, and you, are supporting me?”

I do not wish to enter the community of practice of full-time university-employed academics (as you know), but rather participate in translation of science in the public sphere. Right now, that involves two domains for me: community development or liaison, and secondly NGO work, which would be more oriented toward writing and policy. Perhaps some contracting or consulting work with government would also be a potential. Taking that into consideration, I focus my activities in a number of areas:

i) writing and working towards publishing papers. My goal in this is to present myself as a credible thinker, and emerge from the PhD process with discursive repertoire which will help me in contributing to the talk and practices around “sustainability.”

ii) researching literature in order to have a credible background to be able to speak about that which i am speaking.

iii) Creating a network of colleagues and associates who support me in this work, and provide a “community of practice” starting point for when i graduate.

This third point is especially important to me in this situation because I feel that your ability act as a “God father” and tie me into well-positioned contacts is limited because my potential desired community is different from the ones you traverse.

Thus I spend some time researching and connecting with others who are in the community into which I would like to fit.

I consider this part of my training, and I think you would agree that it is LPP for academics. (and as an afterthought is part of fulfilling the obligations of the SSHRC research grant that pays my wages).

The struggles of which the e mails were a part were experienced also as lack of sleep, panic, anxiety, probably on both sides. What is important here is that both of us worked to move toward clarity. Michael did not label or censure me, but requested my definitions, my terms of our agreement. I have continually attempted to define myself in relation to our shared research project. This is not easy, as I have been and still am exploring my role with respect to the research, the role of research with respect to my own life, present and future. But I could embrace these struggles as not something standing in the way of the development of my career trajectory or an indication of a pathological relationship, but events that were instead crucial to it, and indeed, to be expected, if the theory on which my research is based holds up in practice (Bourdieu, 1992; Lave & Wenger, 1991). This reduced the anxiety-provoking aspects of those experiences. Over time, I realized that I was able to write myself into a community in a

way that was consistent with how I had envisioned it. Through this struggle, I gained competence at declaring who I was and where I wanted to go with my future. I experienced greater security and confidence through this practice.

I was also given support to travel to whatever conferences I chose; this was very important in my exploring what community of practice I was to enter. I have travelled to many different locales, some not typical places for West-Coast students of science education. I was able to travel to Vienna, to attend the social studies of science conference, to Seattle, to attend the “teach-ins” prior to the now infamous protests, to the interior of British Columbia on an “Indian Reserve” to attend a conference on bringing indigenous and scientific knowledge together sponsored by a provincial forestry extension and research agency. Thus not only was I encouraged to imagine and express through writing my career trajectory and potential communities, but I was given means to experience these communities in an embodied sense by attending conferences. This typically self-determined aspect of my graduate studies has been instrumental in facilitating the type of transformation that I had hoped it would do.

Through this process a specific typical mix of activities, a style of writing, a type of theory and a way of articulating and researching questions emerged that could be called my graduate studies research identity (Bakhtin, 1981). By embracing struggle and negotiation as part of the entry into a community of practice, I have seen myself transform the community, and noticed myself becoming transformed. It helps me to surrender my notion of control, of exclusive identification with a certain identity and instead focus on the process of becoming, of negotiating my participation across the many communities which I traverse. By acknowledging *illusio*, the passion, the interest, the deep role participation has with identity, conflicts yield to new creations, identities and possibilities.

Belonging and Becoming and Research – Learning objectivity subjectively

Isabelle Stengers, the well-known Belgian philosopher of science, writes:

Usually sciences are presented, or present themselves, as obeying rational norms. My proposition is just the opposite. There is no general or rational answer to the question, how do fictions become scientifically true? But this does not mean that anything goes. It

means that the question is too important to be left to norms. (Stengers, 2000, p. 49)

I am proposing an approach to the singularity of the sciences in which interest, truth, and history are all indissociable. Whenever the question “Is this scientific?” resounds with regard to an innovative proposition, that question does not oppose scientific truth to opinion. It is a question asked by very interested people who wonder what they may take into account in their own investigation...

The reliability of a scientific result thus depends on the heavy demands of scientists for whom it makes a difference. (Stengers, 2000, p. 48).

These two quotes underscore the importance of an interested, involved community of practice in determining what counts as objective research. She writes: “But what persuades the other scientists is not this particular human, it is their own incapacity to offer another interpretation.” (p. 47) Thus the artifact produced by the scholar must hold up to the practices of verification of the community, which can be as many as there are interested researchers². This definition of what passes as good valid or reliable science allows us to build a space where passion, interest and emotion can co-exist with good, reliable scholarship (Fox-Keller, 1985, chap. 5&6). I, as a researcher, do not need to erase myself from my pursuit, but rather need to strive to generate data and articles that are worthy of acceptance by those researchers whose community I seek to join.

The story of my graduate studies is one not of dispassionately going about collecting objective data, but by being caught up in choices, in conflicts, in activities. I have developed friendships with those I am researching. I have butted heads with my supervisor. I have tried to impose my point of view on the data, and I have had it altered. My journey and experience has been far from dispassionate. I achieve objectivity through the process of writing about my experiences, of analyzing the data that I retrieve in a certain way that is recognized as objective, and by writing with Michael, who is a community member well-versed in the construction of “objective” data. Even though I may be passionate about what the activists are doing, I approach my data in a way characteristic of the community of qualitative researchers. Can my evidence support my

claims? Do my claims make sense given my embodied experience and continued participation with this particular group? Do my claims make sense given my participation with other similar groups? These types of questions remained, uncontaminated by the enthusiasm or passion I had for my work. In fact, they require a deep passion to be persistent and effective.

As I become a researcher and an activist, as I come to belong in a community of practice, I become competent in their practices. And if these practices involve “objective” reporting, then I become competent in these practices in order to fit in with the community. The ability to write objectively becomes an object of passion in and of itself. There is no reason to separate the two. The activity of producing text that is considered reliable, valid or objective is another practice within the community of researchers and writers into whom I wish to be included. Therefore, it is something that I am interested in, it holds for me, *illusio*. I have stakes in being recognized as becoming skilled at this challenging practice. Where there are interests and stakes, emotions and tension will follow.

We cannot discuss the experience of becoming someone new, belonging to a new group of people without involving emotions. They are part of our human physiological experience of being in the world (Pert, 1999). Through the style of training I received, I had a chance to belong somewhere, somewhere I had worked hard to make explicit. Belonging was not signified by being in the presence of others, or of just doing work together, but for me, through explicit acknowledgement of my competence, and after social situations, a recognition that I felt happy, at ease.

10/30/00

(from fellow grad student, UC Berkeley)

Stuart,

Great to hear from you. I was re-reading your paper from last years 4S recently, its one of the best things around, in my opinion.

² Stengers is joined on this contention by a large number of other researchers concerned with science (both natural and social) and objectivity such as Bourdieu, (1990); Latour (1999); Lave, (1988); Law, (1995) and Lynch, (1990).

12/4/00

(from a frequent correspondent, addressed to a mailing list)
The two brightest, most intellectually interesting graduate students I know well right now (not mine, though looking to me for guidance) are neither of them contemplating traditional academic careers. One wants to be an environmental-community activist with some classy credentials, useful for their political clout, and also to explore really new ways of thinking about people and ecosocial networks.

3/2/01

(addressed to potential funders)

But because I think very highly of Stuart as a researcher and colleague, I would like to contribute in getting him set for the time after his dissertation is completed.

Michael

Sometimes I realized that I was doing what I had always dreamt of . This type of recognition is a familiar sign of success to those who study “flow” or optimal experiences (Csikszentmihalyi, 1999; Hennion and Gomart, 1999). Through my experience of belonging, I realized I was becoming – a researcher, an activist, someone who was able to participate articulately. I realized that my interest was bearing fruit.

12/09/99

field notes, from Seattle:

I believed the speakers. I identified with their work. I triumphed with them and supported them in the stories of their travails and wondered at their stamina, energy and intelligence...

Through my participation I felt a group identity, which is both very important and very rare to me... I also enjoyed the multiple tables where there was so much information displayed by all the different NGO's attending. It was good to be able to talk to others...I love NGO women. I find them singularly attractive.

In short, I was in a body state as if I was in love. Secure, stimulated, attracted, nurtured, accepted.

My research ability increases as I am recognized by Michael as a competent researcher and travel with him to new places and begin new ethnographies.

08/05/01

Too bad that you are not yet available. We are beginning our work in the hatcheries in a couple of weeks. Would have good to have your expertise on board.

I learn from doing ethnography alongside someone I definitely have a relationship with. I feel happy when I am able to “capture” a good scene on video, or recognize an aspect of the environment that becomes salient to his thought about it.

05/24/ 01

learned many life lessons from watching Michael do ethnography. Most important is his “aggressiveness” that I would shy away from doing – but how people connect with his direct questions and requests to participate and they all seem really excited to teach and talk to him. Often the talk generates great data. But also the people seem happy and not offended. Very interesting. My feeling is one of expansion.

My learning continues. That feels good. I am becoming a better researcher, more skilled at telling an objective story. Along with the passion, the competence emerges. I find myself in a place that I have worked hard to articulate and become present within.

Conclusion: Graduate studies as Legitimate Peripheral Participation

The features of graduate studies I outlined in the first section were intended to frame some of the personal aspects which I feel are stressed when a participatory approach is taken. There was an emphasis on participating in ways that contributed to discourse, research, and inscriptions that were meaningful to an ongoing research project. I, as a graduate student, was always expected to be participating in the community of scholars who would ultimately judge my scholarship, presented as conference presentations and papers for publication. Six features of this approach were: immediate engagement, scaffolding of activity, an emergent, negotiated research project, theoretical discourse linked to participation with other scholars in the field, involvement in practical details such as equipment purchase and grant crafting, and finally, participation in the reproduction of the culture of researchers among novices. Although these activities are often part of other graduate students’ training, in this example they were the basis for the training and were not supplemented with simulations (such as courses or seminars about grant writing) prior to my engagement. The other strong focus of this activity is that there

was always an emphasis on the graduate student's activity being part of and important to the research unit as a whole. I was constantly aware of the importance of my relations with others on the research team. Through scaffolding, negotiations and struggles, an experience that could be looked back on as an "education" emerged. And I emerged, feeling confident in many of the standard practices of academia.

The second section of this paper examined three aspects of this particular research project that were particular sites for struggle throughout its duration. I argue, though, that by acknowledging the creative potential involved in the struggle, Michael and I were able to benefit from it. The first, concerning struggles about expression, examines an example of how the activity of writing for publication provides a focal point for many other struggles about power and identity within a community. The second section outlines with how an activity approach to identity allows us to articulate non-problematically the dual nature of the LPP I had found myself in during my research as I was becoming both an activist and a researcher. The third section detailed how choosing and articulating the reasons for the balance of activities I took part in played a crucial role in forming my identity as a graduate student embarked on a historically constructed career trajectory. Finally, I frame this style of education as "belonging/becoming," emphasizing the temporally and socially situated nature of the learner. We follow through with speculation on how that places us in terms of valid research.

This article has articulated a first-person experience of a graduate-studies program based on my participation both as a research strategy and a teaching strategy. It highlights some of the practices associated with this type of research training and also implicitly and overtly includes the issues of identity, belonging and emotion that come up through the participation. It is also a conceptualization of identity, not as a "thing" unitary or fragmented but as an outcome, a confluence a sense of being that emerges through the experience of being in a place, with some people and the appropriate non-humans. It tackles the question of "if we eschew a static identity, then what is left?"

It proposes the noticing of embodied experience of the moment, the noticing of struggles, acknowledgement of flow or belonging experiences as learning, as changing participation in ongoing activities. Thus in a language game where transcendental identity is not an issue, we find emotions, activities, struggles, longing, expression and becoming

through belonging. Finally this article confronts how the inclusion of these embodied experiences of learning and doing research may problematize the writing of research. The usual discourse of validity (and much of information processing-based learning) assumes an objective, unaffected researcher. By including struggles, contingency and emotions into the discourse about research, we challenge that notion.

I include raw data which tells its own stories; the voices and actions are allowed to speak directly, and add potentially multiple layers of alternative meaning into the story. I give you the reader access to a different set of authors telling stories meant to support this commentary. You may not agree with my analyses, or see other patterns I do not comment on. That is part of the utility and exciting promise that technique holds. By presenting the “thick” data on which I base my discourse, I allow myself to be seen as an author engaged in a work of thinning or telling a story about certain data. It foregrounds the active nature of the text and lays my interpretive strategies open for inspection, contestation. It encourages you, reader, to thicken this account with a denser network of articulations and propositions about the text and come away from this experience of reading with a more complex and indeterminate understanding. One that is supported by the structure and style of the article itself.

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Appendix One

Ethics Approval Form



University of Victoria
Human Research Ethics Committee

CERTIFICATE OF APPROVAL

<u>Principal Investigators</u> Dr. Wolff-Michael Roth Faculty	<u>Department/School</u> SNSC	<u>Supervisor</u>	
<u>Co-investigator(s):</u> ✓ Stuart H. Lee, PhD Student	SNSC		
THE UNIVERSITY OF VICTORIA HUMAN RESEARCH ETHICS COMMITTEE			
<u>Project No.</u> 120-99	<u>Start Date</u> 09 Apr 99	<u>End Date</u> 08 Apr 00	<u>Approval Date</u> 09 Apr 1999

Certification

This is to certify that the University of Victoria Ethics Review Committee on Research and Other Activities Involving Human Subjects has examined the research proposal and concludes that, in all respects, the proposed research meets appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Subjects.

J. Howard Brunt,
Associate Vice-President, Research

This Certificate of Approval is valid for the above term provided there is no change in the procedures. Extensions/minor amendments may be granted upon receipt of "Request for Continuing Review or Amendment of an Approved Project" form.

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Appendix Two

Copyright Release Forms

To whom it may concern:

as one of the chapters in Stuart Lee's dissertation has already been modified, accepted for publication, and recently appeared, I am releasing any copyrights I might have on this article to Stuart Lee.

The specific piece is:

Lee, S., & Roth, W.-M. (2001). How ditch and drain become a healthy creek: Representations, translations and agency during the re/design of a watershed. *Social Studies of Science*, 31, 315-356.

Sincerely,

Wolff-Michael Roth

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CANADA

Dear Stuart Lee,

Lee, S. and Roth, W., "How Ditch and Drain Become a Healthy Creek : Re-Presentations, Translations and Agency during the Re/Design of a Watershed ."
in *Social Studies of Science*, Vol. 31(3), 2001, pp. 315-356

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do I have your permission to do this? It will appear in a bound copies of the dissertation and will be microfilmed for achival purposes in the National Library of Canada.

Thank you
Stuart Lee